BUILD A 40-MHz DIGITAL FREQUENCY COUNTER

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16-PAGE BONUS!

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Test Instruments

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HOW TO BUILD A LOW-COST DIGITAL IC TESTER

Telephone Answering Breakthrough

Let a new remote control answering computer free you from your next telephone call.

It's a telephone answering computer. The Ford 820 has the first large-scale integration of solid-state componentry which marks a major change in telephone answering systems since the first mass consumer models appeared five years ago. This means more features, lower cost and greater dependability. Here are some of its exciting features:

Forget about tapes There are no tapes to buy. The Ford unit has a special polymer-based magnetic tape that will record over 25,000 phone calls without replacement. That's over five solid years of use. There are no cassette tapes to buy, wear out or replace.

Forget about microphones When you want to change or record your message, just press a red button, record your message and let go. The message (any length up to 30 seconds) will record and be immediately ready to playback since the message tape does not have to recycle. There are no separate microphones or level controls since the built-in microphone automatically adjusts to your voice.

Forget about touching it You can adjust your unit to answer on either one or four rings. When the unit is set on four rings and you reach the phone before the 820 answers, you will not activate the unit. But let us say you're outside or indisposed. No problem. The Ford 820 will automatically answer after four rings. This means that your unit can always be "alive" in the four-ring position so you never have to remember to set it whenever you leave your home or office.

Forget about going home Just bring your optional remote control pager with you. If you want your messages while you're on vacation or away, call your number and the coded pager will remotely signal your unit to play back all your messages.

Forget about service If you've owned a telephone answering device for more than a year, there's a good chance that it's been in for service at least once. The Ford unit, however, is solid state and built with the same heavy duty components Ford uses in its commercial unit. It should dependably stand up to years of heavy usage. (Ford Industries is the world's largest supplier of telephone answering equipment for the Bell system.) If service is ever required, there are over 200 authorized service centers plus a service-by-mail center. There's also a toll-free "Help-Line" number to call 24 hours a day for advice or suggestions, and your unit has a limited one year parts and labor warranty.

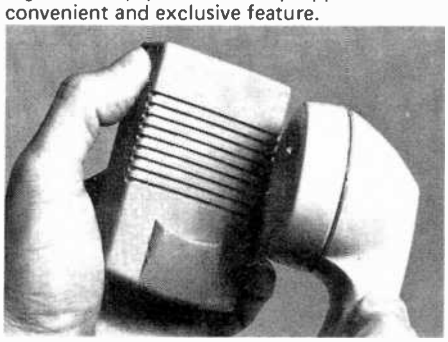
The entire printed circuit-board with its integrated circuits is easily replaceable and contains the "Brains" required to control the audio amplifier and tape transport system.

PLENTY MORE FEATURES

The Ford 820 has a monitor feature—you can listen to the caller leave his message and pick up the phone to intercept the call. If you want to skip over a message on the tape, just tap a button and it fast-advances to the start of the next call. It has a selectable erase feature that lets you erase a specific message or the entire tape if you wish.

KNOW HOW MANY CALLS

With other answering machines, you never know how many calls you receive until you play them back. With the Ford 820 you have a call counter—a device that displays the exact number of calls you've received when you arrive home. If you now own another answering machine, you can really appreciate this convenient and exclusive feature.



Hold the small pocket-sized remote-control pager up to any telephone in the world and you can playback all your messages.

The Ford unit is the first really versatile answerer that works equally well at home or in the office. It's perfect for the busy or working housewife who spends little time at home. And, if she's home and just plain busy when the phone rings, she can always call back later without offending the caller.

The executive can now leave his office, call from the field and get all his messages. An inefficient operator at a telephone answering service may offend your customers by putting them on hold. The Ford 820, however, takes your message quickly—without delay.

There are very few people who haven't left a message on a telephone answering machine, and callers really appreciate the convenience.

NO PHONE COMPANY TARIFFS

The Ford unit is equipped with an FCC-approved interconnect device so your unit is actually welcome on your phone line. The 820 comes with a four-pronged plug so you just plug it into your phone jack. If you don't have a phone jack, just call your phone company and tell them you are purchasing an approved Ford unit and that you want a four-pronged jack for your phone. They'll know exactly what you want and charge you around $12 for the installation, depending on where you live. If you have a multi-line phone, they can install a jack to tie into any or all of the lines you wish. There are no additional monthly charges.

STANDING BEHIND A PRODUCT

JS&A lets you use the 820 in your home or office for one full month. Use it to screen your calls, take messages while you're gone or as a back up system when you're busy. Use the remote pager and retrieve calls while you're out. See how easy it is to change the message in seconds, and see how much it uncomplicates your life. Use it under your everyday conditions at home or at your office and then decide after one month whether or not you want to keep it. If you decide to keep it, you'll own the best. If not, return your unit for a full and prompt refund. There is no risk. Even if you already own a phone answerer, it would pay for you to see how much better the 820 performs.

JS&A is America's largest single source of space-age products and a substantial company —assurance that your purchase is protected.

The Ford 820 comes in two models: the Remote Control unit for $259.95 called the 820P and the same unit without the pager but with all the other features for $179.95 called the 820S. Simply select the unit you want and send your check for the correct amount to the address shown below. Credit card buyers may phone in their orders by calling our toll-free number below. (Illinois residents add 5% sales tax.) There are no postage and handling charges.

By return mail, you'll receive the Ford unit complete with all connections and instructions (and pager with remote unit) plus your one year limited parts and labor warranty. The unit measures 3¼"x 8½"x 12" and weighs six pounds.

The Ford 820 compares to units that sell for much more but do not have the simplicity and the advanced electronics. Don't be confused. The Ford 820 is the finest telephone answerer you can buy at any price and is years ahead of all other conventional systems.

JS&A gives you everything you could possibly expect from a telephone answering system: 1) A unit years ahead of every other unit at a very reasonable price. 2)A service network that covers the United States with repair centers and free telephone assistance. 3)The chance to buy a unit in complete confidence, knowing that you may return it without being penalized with a postage and handling charge if it's not exactly what you want. You can't lose.

Computer technology has even touched the telephone answerer. Now is the best time to get the finest system available. Order your Ford 820 without obligation, today.

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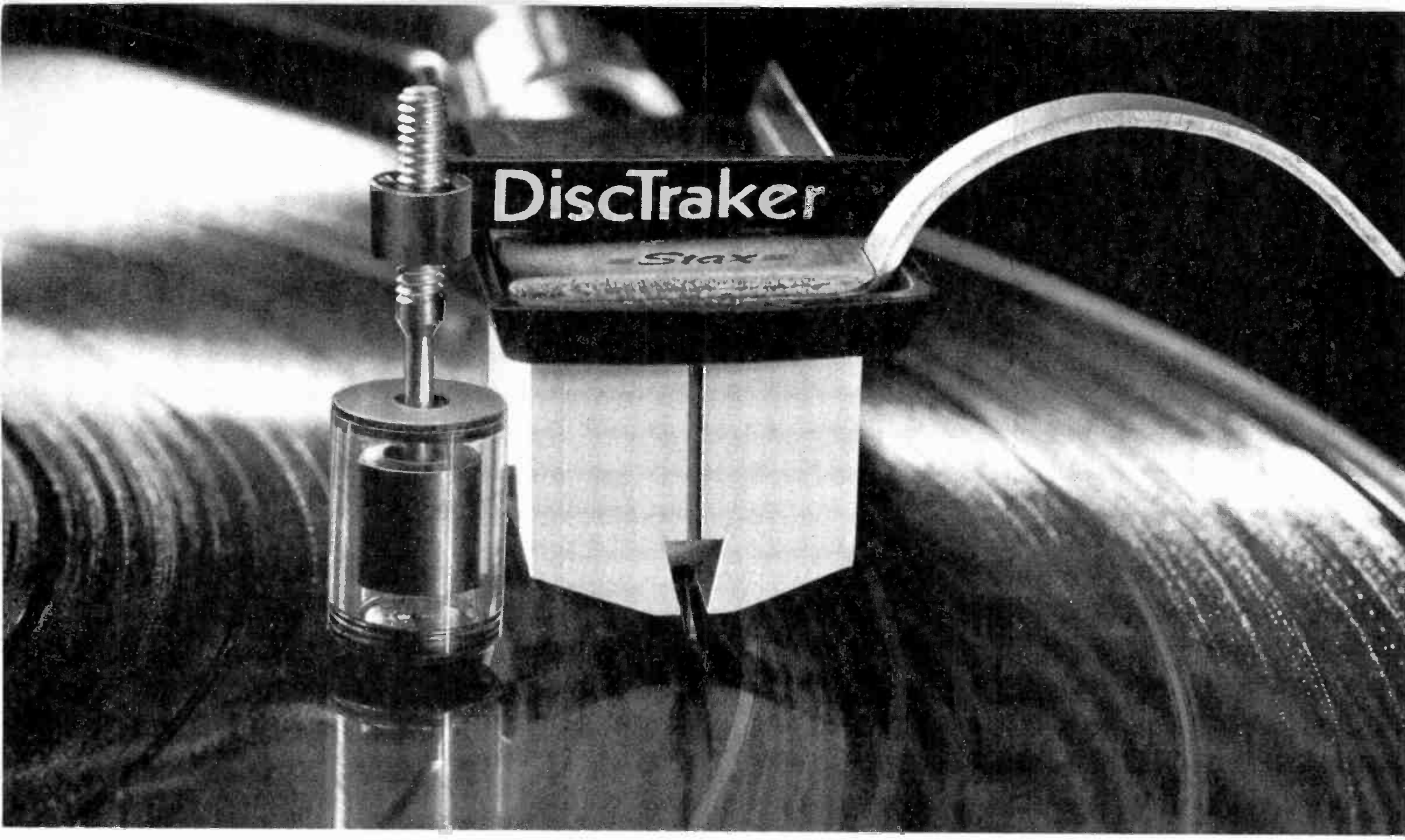
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JUNE 1977 VOLUME 11, NUMBER 6

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COLUMNS

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ELECTRONIC PRODUCT TEST REPORTS

DEPARTMENTS

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Editorial

TV FOR RADIO AMATEURS

Amateur TV (ATV) experimenters are a hardy group. For decades now, a small number of hams have been working with on-the-air television, enjoying high-quality video. With the lowering of TV camera prices, and the availability of relatively inexpensive surplus equipment that can be modified for use in the 420-MHz ATV band, more hams are taking a closer look at this interesting communication area.

As many readers know, there's a wide difference between the bandwidth of a single channel of ATV and one of slow-scan TV. The narrow-band SSTV system used in the 14-MHz and hf and vhf bands require about eight seconds to "paint" a full, low-resolution picture on the face of a CRT. In contrast, ATV video has virtually an instantaneous format with commercial TV standards. Unlike SSTV, however, ATV has a fairly short communication range due to its restriction to uhf amateur bands. Consequently, the virtue of commercial-TV picture quality is countered by the absence of long-distance contacts. Therefore, it's interesting to note that a petition was filed with the FCC this year for establishing a new community educational radio fixed service (CERFS), called "Communicasting," that proposes the use of frequencies in the 470-to-930-MHz band, preferably commercial TV channels from 70 through 83. It's conceivable that hams could assist legitimate agencies to transmit if such a proposal is ever adopted. This would certainly spark the growth of ATV, as well as build a pool of technically trained "communicasters."

The petition outlines the use of repeaters to cover communities for educational and public service purposes, emphasizing the cost effectiveness of such a service in the vhf/uhf region as compared to the established "Educational Radio Service" in the 2.5-to-2.69-GHz band, where equipment costs are prohibitively high. The proposal cites an example of two-way communication for educational purposes that was carried out by a medical college.

The proposal—spearheaded by Ed Pillar (W2KPQ), an active ATV'er, and Dr. Lee Cohen (WA2RPC), an educator—is certainly an interesting one. Since most of the allotted uhf channels around the country are not used, the resource would not be wasted. On the other hand, broadcasters and cable-TV operation would doubtlessly object.

There are local educational and public service audio/video communications that will probably never be attempted by professional broadcasters, of course. I cite local school board budget meetings, as an example. Could or should this type of telecasting be effected on existing uhf channels? It would clearly be an efficacious way to bring "communicasting" to local communities, although the logistics problems that would ensue could be most challenging. Or, alternatively, should another frequency band, below the gigahertz one, be allotted for the aforementioned purposes?

You can express your comments (an original and five copies) on the proposal (petition No. RM-2846) by June 13 to the Federal Communications Commission, Washington, DC 20554.

Art Salsberg

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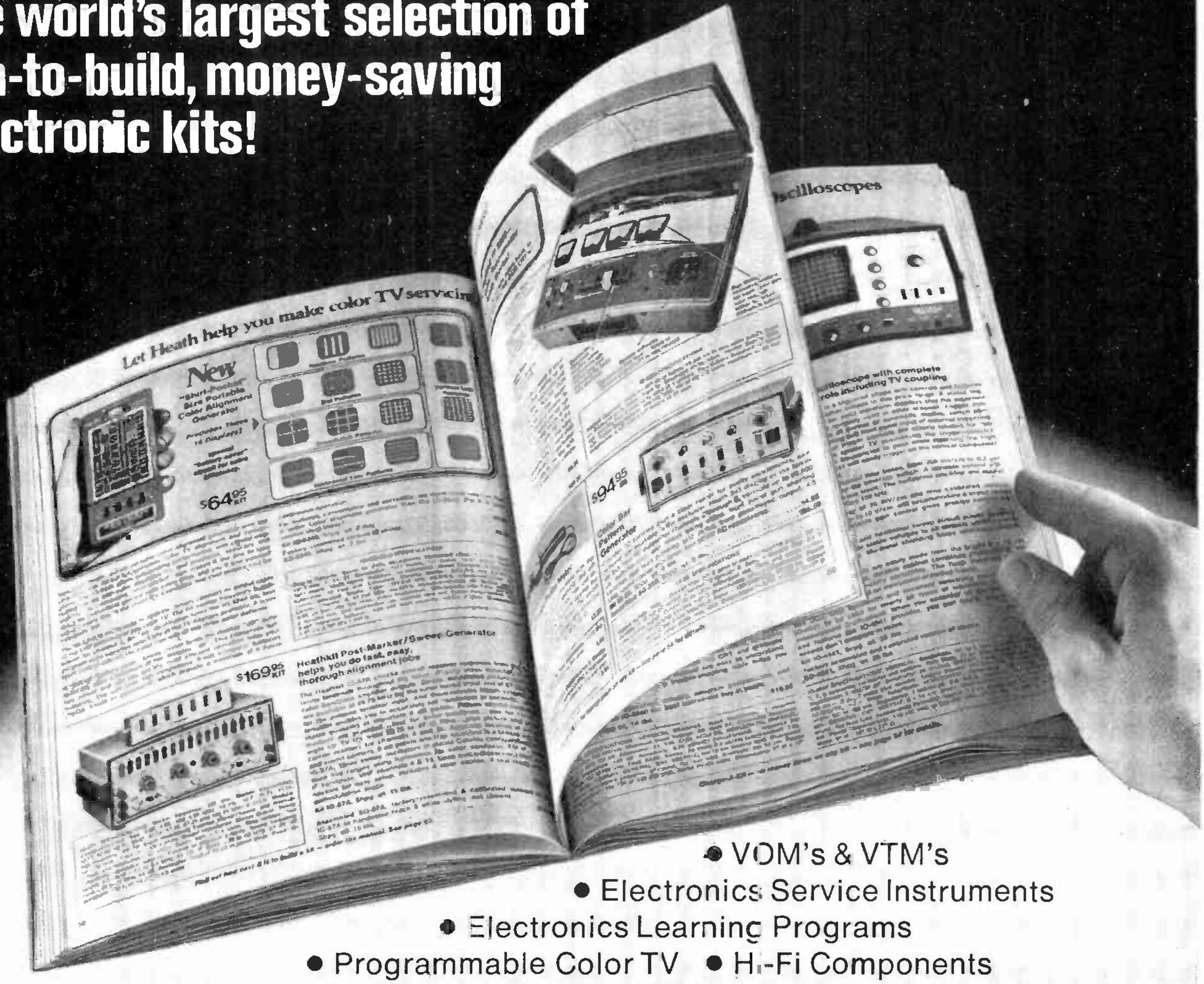

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Letters

SWAMPFELDER STRIKES AGAIN!

In the "April Hobby Scene," you have casually dropped a scientific bombshell! Marcia Swampfelder describes a device called the "in situ" solar cell. This story, if true, is the economic equivalent of "How to Turn Sand Into Gold for a Few Dollars and a Day's Work." In one fell swoop, it obsoletes 65 million dollars worth of 1977 ERDA contracts for solar cell research. However, it has a certain hoax-like quality to it. I'm no chemist, but after diagramming the molecule for the long-named "reactive agent" described, I get something that looks a lot like common motor oil.—*Clyde R. Smith, Fort Worth, TX.*

Marcia Swampfelder's masterful ideas appear only in April each year, brimming with the spirit of April Fool's Day. The low-cost solar cell described was simply one of the many implausible items presented.

ALTAIR MONITORS

Regarding your article about computer monitors ("Computer Bits," April 1977): (1) The 680b Monitor was not written by Micro-Soft, as stated. It is a highly modified version, developed by MITS, of Motorola's Minibug. (2) The modifications required to run software written for Mikbug with the 680b Monitor are trivial, especially since a source listing of the monitor is included with the Altair 680b computer. Thus, there is no reason to run anyone else's software on the 680b.—*Mark Chamberlin, MITS, Albuquerque, NM.*

DON'T SILENCE SOME RADIOS

The article "Build a Silencer" (March, p 57) contains instructions that will cause malfunction and possible damage if applied to certain GM-Delco radios. Our newest AM/stereo FM radio and tape combination units use bridge audio IC's that do not use chassis ground for the speaker system, nor do they share a common speaker return. Each audio channel is served by a separate IC, with two wires to each ungrounded speaker. The modifications proposed in the article would tie the IC modules together and cause extreme distortion, high current drain, and might permanently damage the bridge IC modules. The Silencer should not be used with the bridge audio circuits in our 1976 and 1977 stereo radio and tape products.—*David A. Cox, Delco Electronics, General Motors Corp., Kokomo, IN.*

"MORSE-A-LETTER" BOOSTER

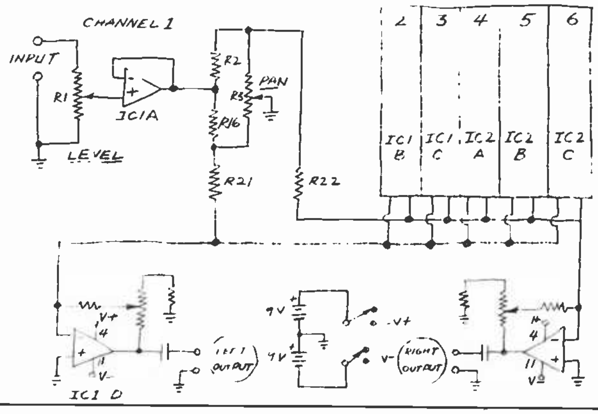
I have nothing but praise for the "Morse-A-Letter" project (January 1977). I built my project from the very reasonably priced kit supplied by Select Circuits. I must say that this was the most enjoyable and well-presented project I have come across. When I called Mr. Sievert for some help on a problem I encountered (my own fault), I was impressed with his attitude and interest. I wish more company representatives had the same attitude toward customer satisfaction. I highly recommend the "Morse-A-Letter" and the Select Circuits kit to anyone who wants a great project.—*Robert F. Miller, Wolcottville, IN*

OF "ELVES" AND COMPUTERS

The "Cosmac 'Elf'" microcomputer construction article (August 1976) must be your best project yet. I am in the process of upgrading to 4k memory, and I am planning to add a cassette tape interface. Also, keep those Computer Bits columns and programming articles coming.—*Stanley W. Pozerski, Jr., Lowell, MA.*

BUILDING A BETTER PAN/MIXER

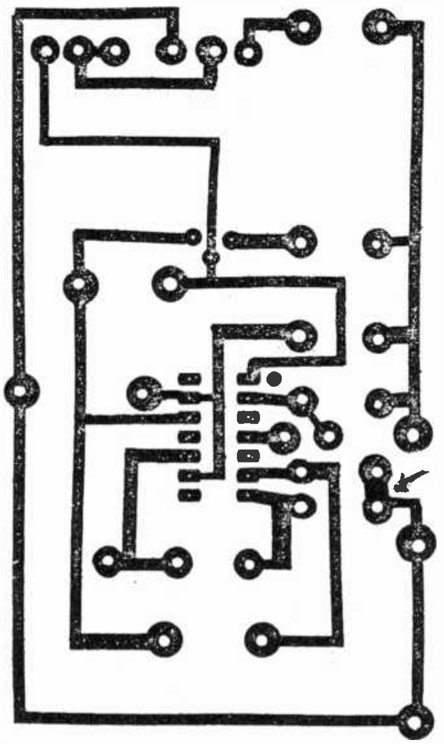
In the Pan/Mix article (October 1976), it was stated that the INPUT LEVEL potentiometer presents a constant 10,000-ohm resistive load on the output of the signal sources. This is incorrect, since the input resistance depends to a great extent on the settings of the INPUT LEVEL and PANNING controls. The highest possible resistance is indeed 10,000 ohms, but only when the INPUT LEVEL control is at minimum; the lowest resistance of 3750 ohms occurs when the control is all the way up. To overcome this problem, I have devised a circuit (see schematic diagram) that can be added to the project. By using two low-power quad op-amps, such as the LM324, it is possible to have six input channels, keep the supply current to a minimum, and maintain a constant 10,000-ohm input resistance. Since the input bias current is only 0.25 μA maximum, the op-amp does not present any loading effect on the INPUT LEVEL potentiometer.—*Richard DeLombard, Toledo, OH*



Out of Tune

In "Westminster Clock" (November 1976), the point labelled H in Fig. 3 should be connected to pin 13 of *IC19* in Fig. 1 (not to pin 6 as shown). Also, if you are unable to find the specified displays for *DIS1* through *DIS4*, you can substitute Radio Shack No. 276-065 fluorescent display tubes.

In "A/D Temperature Converter" (December 1976), there is an error in the etching and drilling guide shown in Fig. 2 in the area of *D1*, *R7*, and *R8*. The corrected guide is shown below.



In "Build a 10-Hz to 1-MHz Eput Meter" (March 1977), the values of resistors *R5* and *R8* are specified incorrectly in the Parts List. (They are correct on the schematic.) They should be, respectively, 22,000 and 10,000 ohms.

In "LED Racing Game" (March 1977), the foil traces for the V_{CC} pads (pins 16) of *IC6*, *IC7*, and *IC8* are missing from the etching and drilling guide in Fig. 6. Connect these pads directly from the V_{CC} bus to the pin-16 pads exactly as shown for the *IC5* location.

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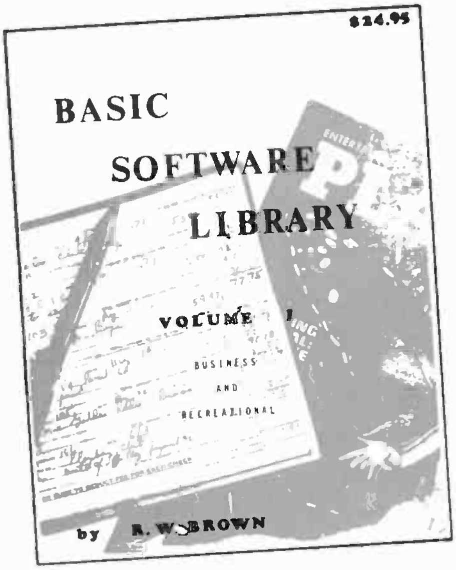

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This library is the most comprehensive work of its kind to date. There are other software books on the market but they are dedicated to computer games. The intention of this work is to allow the average individual the capability to easily perform useful and productive tasks with a computer. All of the programs contained within this Library have been thoroughly tested and executed on several systems. Included with each program is a description of the program, a list of potential users, instructions for execution and possible limitations that may arise when running it on various systems. Listed in the limitation section is the amount of memory that is required to store and execute the program.

Each program's source code is listed in full detail. These source code listings are not reduced in size but are shown full size for increased readability. Almost every program is self instructing and prompts the user with all required running data. Immediately following the source code listing for most of the programs is a sample executed run of the program.

The entire Library is 1100 pages long, chocked full of program source code, instructions, conversions, memory requirements, examples and much more. ALL are written in compatible BASIC executable in 4K MITS, SPHERE, IMS, SWTPC, PDP, etc. BASIC compilers available for 8080 and 6800 under $10 elsewhere.

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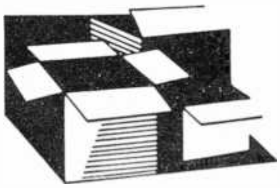
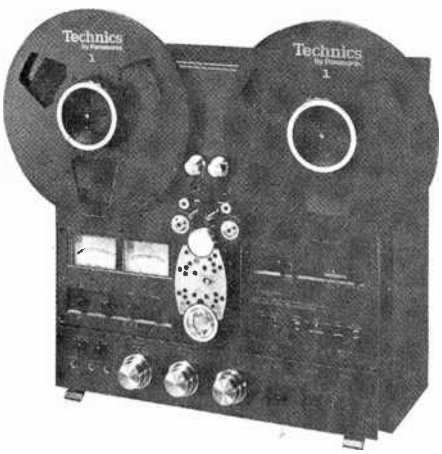


New Products

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Reader Service Card inside the back cover or write to the manufacturer at the address given.

TECHNICS OPEN-REEL DECK

The Technics Model RS-1500US "isolated loop" direct-drive tape deck is said to isolate completely the tape loop from all outside influences such as take-up and back tensions exerted by the reels. The loop is driven directly by a 3.6 rps dc motor (at tape speed of 15 ips) locked to a quartz-crystal servo circuit.



Wow and flutter is 0.018% W rms. The head configuration includes a 4-track playback head, 2-track erase, 2-track record, plus 2-track playback. Other features include separate three-way adjustments of recording bias and equalization, average-reading VU meters that also indicate playback levels, timer for unattended recording, and edit dial (just below the heads) that simplifies editing and splicing. Maximum reel size is 10½ in., and speeds are 15, 7½, and 3¾ ips. Measures 18"W × 17½"H × 10⅛"D (45.6 × 44.3 × 25.7 cm). $1500.

CIRCLE NO. 89 ON FREE INFORMATION CARD

E.F. JOHNSON AM/SSB CB TRANSCEIVER

E.F. Johnson's new 40-channel Viking 4740 mobile CB transceiver features both AM and SSB operation, LED numeric channel display, and color-keyed indicator lights for mode selection (AM, USB, LSB). The display also features a dimmer switch for subdued nighttime use. Other features include an illuminated S/r-f meter, built in anl, switchable noise blanker, and PA function. A crystal lat-

tice filter is said to provide a high degree of adjacent-channel rejection. On transmit, a speech compressor increases average modulation levels. The clarifier or "fine-tune" control is claimed to have exceptionally smooth operation and a center-notch position for easier adjustment. $359.95.

CIRCLE NO. 91 ON FREE INFORMATION CARD

SUPEREX POWER MICROPHONE FOR CB

Superex's Model PV-1 CB power microphone features an electret cartridge and a self-contained FET preamplifier and power amplifier.

The single 1.5-volt penlight cell that powers the amplifiers comes with the mike. A special no-solder connector is supplied for attachment of the mike to CB transceivers. Also provided with the mike are a 6' (1.8-m) coiled cord and complete installation instructions. $34.95.

CIRCLE NO. 92 ON FREE INFORMATION CARD

MITSUBISHI POWER AMPLIFIERS

Mitsubishi is marketing two "dual-monaural" (stereo) power amplifiers said to have better than 80-dB channel separation. Models DA-A10 and DA-A15 are rated at 100 and 150 watts/channel, respectively. They are designed to be "docked" with the company's Model P10 dual-monaural preamplifier or Model M10 power level meter. According to Mitsubishi, the dual-monaural scheme effectively eliminates crosstalk while improving channel separation by as much as 30 dB or more over conventional designs. Both amplifiers feature high-capacity separate power supplies, wide dynamic response and range, distortion-reducing circuitry, special heat sinks, and circuits to protect against low-load impedance and dc potentials. Model DA-A10, $390; Model DA-A15, $590.

CIRCLE NO. 100 ON FREE INFORMATION CARD

HUSTLER CB BASE-STATION ANTENNA

New-Tronics' Model HP-27 Hustler "Homing Pigeon" CB base-station antennas are for operation in places where outside antennas are either impractical or prohibited. No installation is required. The antenna is supported between the floor and ceiling of a room in the same manner as a pole lamp. Performance is said to be equal or superior to the best mobile antennas. Two free-sliding sleeves quickly

and easily adjust the antenna to resonance and optimum SWR. Once adjusted, the SWR is said to be well below 2:1 over the entire 40-channel CB range. The antenna is supplied with 17' (5.2 m) of coaxial cable to which connectors are attached at the factory. $42.95.

CIRCLE NO. 93 ON FREE INFORMATION CARD

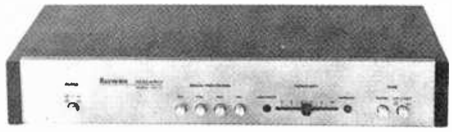
AEC FUNCTION GENERATOR

Available in both kit and wired forms, the AE Corp Model 21 function generator offers a 1-Hz to 1-MHz range with 5% accuracy and 200 ppm/°C stability. Sine, square, and triangle output waveforms are switch selectable. The output is continuously variable from 0 to 20 volts p-p open-circuit (10 volts p-p into 100 ohms) and can be dc offset by as much as ±10 volts. There are also separate fixed 5-volt TTL square-wave and 4-volt p-p triangle-wave outputs. In addition, the generator features external frequency control vco with a range from dc to 1 MHz. External control also permits the instrument to deliver FSK (frequency-shift keyed), FM, and tone-burst modulated signals at the output. $124.95 wired, $79.95 kit.

CIRCLE NO. 94 ON FREE INFORMATION CARD

BURWEN DYNAMIC NOISE FILTER

The new Burwen Model DNF 1201A dynamic noise reduction system is said to provide up to 30 dB of noise reduction at 10,000 Hz with 5 to 14 dB of overall hiss reduction. A bandwidth controller circuit measures the high-frequency content of the sum of the left and right inputs from the source material and adjusts



the bandwidth in accordance with both level and frequency. Dynamic filtering is achieved as the bandwidth controller generates dc control voltages to constantly regulate the cutoff frequency of the filter. The low-pass filter's cutoff frequency varies between 500 and 30,000 Hz, in accordance with source requirements. Attenuation rate is 9 dB/octave, and claimed dynamic range is 96 dB. The system operates without requiring encoded signals and is designed to selectively reduce noise without destroying fidelity or high-frequency content.

CIRCLE NO. 95 ON FREE INFORMATION CARD

ELAC BELT-DRIVEN TURNTABLE

The Model PC 830 is Elac's first belt-driven turntable. It features idler-wheel assist for start-up and cycling, two pushbuttons for simplified operation in either the single-play or the multi-play modes, new low-mass tone-

arm, and illuminated stroboscope. The idler wheel assist brings the massive 4.4-lb (2-kg) platter up to speed quickly. The anti-skating control is calibrated separately for conical, elliptical, and CD-4 styli. Operating speeds are 33⅓ and 45 rpm, both of which can be adjusted by up to ±3% with a vernier control. Wow and flutter are DIN rated at 0.08%, rumble at better than 44 dB unweighted (64 dB weighted). Tracking error is rated at less than 1.4°. Size is 17⅛"W × 13¾"D × 6⅞"H (43.5 × 35 × 17.5 cm). Supplied with automatic and manual spindles, the turntable sells for $189.95.

CIRCLE NO 96 ON FREE INFORMATION CARD

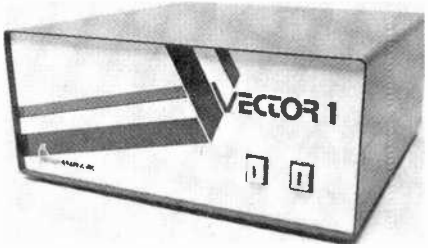
SPARKOMATIC DELUXE CB BASE STATION

The 40-channel Model CB-1500 AM CB base station from Sparkomatic Corp. features a PLL digital frequency synthesizer, seven-segment LED channel display, and ac/dc operation. The deluxe station includes continuously variable fine tuning, tone control, r-f gain control, noise blanker (NB) switch, automatic noise limiter (anl) switch, and an SWR indicator. Other features include: illuminated modulation-percentage meter, S/r-f meter, transmit/receive/antenna-warning indicator lights, and a headphone jack, PA function switch and external speaker jacks. The built-in, 5-in. speaker faces front. The transceiver is housed inside a solid teak wood cabinet.

CIRCLE NO. 97 ON FREE INFORMATION CARD

VECTOR GRAPHIC MICROCOMPUTER

The Vector 1 microcomputer from Vector Graphic Inc. comes in a custom cabinet that contains an 18-slot, 100-point motherboard with six connectors, power supply (8 volts at

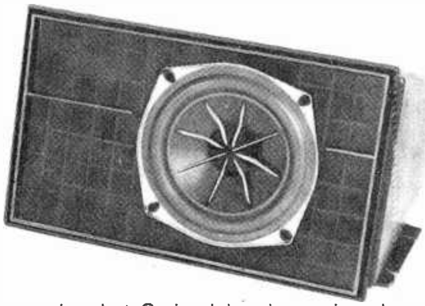


18 A and ±16 volts at 2 A), whisper fan, and guides and supports for six cards. The 8080-microprocessor-based CPU board has 8-level vectored priority interrupts, current-status register, and dual-mode realtime clock. The PROM/RAM board contains 1K of RAM and has room for an additional 2K of 1702A type ROM. Included is a 512-byte monitor for use with Tarbell cassette and Altair™, IMSAI, and Polymorphic I/O board and terminal or video board, keyboard, and monitor. $849 factory assembled, $619 kit.

CIRCLE NO. 98 ON FREE INFORMATION CARD

CRAIG CAR STEREO SPEAKER

Craig's Model R780 surface-mount speaker system for cars, part of a line called Trans-Rib™, features a light-mass cone, long-thrust acoustic driver, and special support and sound transmission "ribs." The ribs are supported at the speaker's cone center by the voicecoil and extend outward to distribute all frequencies over the entire surface of the



cone in what Craig claims is precise phase coherence. Additionally, the structural strength afforded by the Trans-Rib elements is said to turn the cone into a rigid true piston for solid bass sounds. Handles up to 50 watts. $99.95.

CIRCLE NO. 87 ON FREE INFORMATION CARD

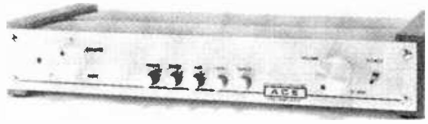
NLS 512-MHZ COUNTER PRESCALER

The Model SC-5 is a compact 512-MHz prescaler designed specifically for the Non-Linear Systems Model FM-7 frequency counter. However, it can be used with any other frequency counter that has a 50-ohm input. Frequency accuracy is stated as being one part per million (1 ppm). Input sensitivity is rated at 30 mV. Supplied with a coaxial input probe that can be used to make direct tests in circuits or proximity tests from antennas in many circuits, the instrument also comes with an interconnect cable for the Model FM-7 frequency counter. Size is 4"D × 2.7"W × 1.9"H (10.2 × 6.9 × 4.8 cm). $127.00, including rechargeable battery and charger.

CIRCLE NO. 99 ON FREE INFORMATION CARD

ACE STEREO PREAMPLIFIERS

Two new deluxe stereo preamplifiers are currently being marketed by ACE Audio Co. Designated the Models 3000 and 3100, the preamps feature completely new circuitry that uses both discrete operational amplifiers and integrated circuits and shielded power supplies with dual IC regulators. Both are designed for very low distortion, said to be in the



region of 0.01%. The Model 3000 contains a built-in power supply, while the Model 3100 has its power supply located in an external box. The low-profile preamps also feature aluminum knobs with solid walnut end caps, pushbutton source selector switches, and large knobs for the BALANCE and VOLUME controls. Model 3000, in kit form, $156; wired, $250. Model 3100, wired only, $325.

CIRCLE NO 88 ON FREE INFORMATION CARD

COMING UP IN THE JULY

Popular Electronics®

VIDEO GRAPHICS PROJECTS:
- LATEST TV TYPEWRITER
- ANIMATION FROM "ELF" MICROCOMPUTER

"ZAP" NEW LIFE INTO DEAD NiCd BATTERIES

HOW TO MAINTAIN TAPE RECORDERS IN PEAK CONDITION

DECIPHERING UTILITY CODE BROADCASTS WITHOUT MORSE

TEST REPORTS:
Radio Shack STA-2000 Stereo FM/AM Receiver
Koss K-145 Stereo Headphones
Cobra 29XLR 40-Channel AM CB Mobile Transceiver

IT TAKES A VERY SPECIAL CASSETTE DECK TO GET SO MUCH BEAUTIFUL MUSIC OUT OF SOMETHING THIS LITTLE.

The recording tape in a cassette is only an eighth of an inch wide.

Crammed into that eighth of an inch may be as many as 64 tracks mixed down to two. A hundred musicians. Countless overdubbings. Not to mention the entire audible frequency range.

Any cassette deck can reproduce part of what's been put down on that eighth of an inch.

But the Pioneer 9191 was designed to reproduce all of it. Superlatively. Without dropouts, unacceptable tape hiss, or noticeable wow and flutter.

Take our tape transport system, for example.

Since the tape in a cassette moves at only 1-7/8 inches per second, even the most minuscule variation in tape speed will make a major variation in sound.

To guard against this, where most cassette decks give you one motor, the 9191 comes with two. The first is used only for fast forward and rewind, so the second can be designed exclusively to maintain a constant speed for play and record.

All of our tape drive components—the capstan, belt, and flywheel—are finished to incredible tolerances. Which give the 9191 the kind of wow and flutter figures that no deck in our price range can match.

Of course, having a great tape transport system means nothing if you don't have great electronics to back it up.

We do.

The 9191 comes with an advanced three stage direct coupled amplifier that extends high frequency response and minimizes distortion. The built-in Dolby system can reduce tape hiss by as much as 10 decibels in high frequencies.

Our multiplex filter lets you record

FM broadcasts without picking up a lot of unwanted noise, or the multiplex signal every FM stereo station sends out.

Even our ferrite solid tape head offers the best combination of accuracy and long life you can get in a cassette head.

We also include a peak limiter to let you cram as much onto a cassette as possible without distortion. A memory that lets you go back to a favorite spot on the tape automatically. Separate bias and equalization switches for getting the most out of different brands of tape. And electronic solenoid controls for going from play to rewind, or from rewind to fast forward, without hitting the stop button. And without jamming the tape.

Go slip a cassette into a Pioneer 9191 at your local Pioneer dealer.

You'll find it hard to believe such a little thing could come out sounding so big.

CT-F9191 Specifications

Frequency Response: Standard, LH tape: 25-16,000 Hz (35-13,000 Hz ±3dB), CrO_2 tape: 20-17,000 Hz (30-14,000 Hz ±3dB)

Signal-to-Noise Ratio: Dolby OFF: More than 52dB: Dolby ON: More than 62 dB (Over 5,000 Hz Standard and LH tapes/When chromium dioxide tape is used, signal-to-noise ratio is further improved by 4.5dB over 5KHz).

Harmonic Distortion: No more than 1.7% (OdB)

Wow and Flutter: No more than 0.07% (WRMS)

Motor: Electronically-controlled DC motor (built-in generator) x 1; (4.8 cm/s speed drive), DC torque motor x 1; (Fast forward and rewind drive)

U.S. Pioneer Electronics Corp., 75 Oxford Drive, Moonachie, New Jersey 07074

PIONEER®
High Fidelity Components

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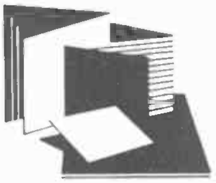


New Literature

SEMICONDUCTOR GUIDE SUPPLEMENT

GTE Sylvania offers a 16-page supplement to its ECG Replacement Catalog. Replacements for more than 3,000 devices used in domestic and foreign equipment are described, including both modules and monolithic integrated circuits. All part numbers are listed in alphanumeric order and cross-referenced to equivalent Sylvania replacements. Guide and supplement are available from GTE Sylvania distributors.

CB ACCESSORIES CATALOG

Siltronix offers a 12-page catalog describing its line of Citizens Band radio accessories. Products include meters, antennas, antenna accessories, speakers, desk mikes and mobile mounting kits. Address: Siltronix, 330 Via El Centro Ave., Oceanside, CA 92054.

RCA CMOS B SERIES GUIDE

RCA offers a 24-page guide to its B series of COS/MOS high-voltage integrated circuits, Guide COS-278F. The booklet describes the devices and provides standardized static electrical characteristics information and function classification, selection charts and diagrams. Special information on standard timing circuits is also included. Address: RCA Solid State Division, Box 3200, Somerville, NJ 08876.

JENSEN HARD-TO-FIND TOOLS

A 136-page catalog from Jensen Tools and Alloys lists over 3,000 hard-to-find tools. Categories covered include micro-tools, test equipment, soldering equipment, screwdrivers, cutters and power tools. A 32-page section features tool kits and cases, and a "Jensen Tool Tips" supplement provides technical data to aid in tool selection. Address: Jensen Tools and Alloys, 4117 North 44th St., Phoenix, AZ 85018.

TSC COMPUTER SOFTWARE CATALOG

Technical Systems Consultants' catalog of hobbyist computer software includes programs for games as well as practical applications. All are written in assembly language and intended for use with the 6800, 8080 and 6502. Catalogs are 25 cents each. Address: Technical Systems Consultants, Box 2574, W. Lafayette, IN 47906.

ROYCE CB CATALOG

Royce Electronics offers a 40-page catalog describing its line of 40-channel AM and SSB CB transceivers, antennas and accessories. Items featured include CB mobile and base transceivers with solid-state modular chassis construction, and a new 40-channel in-dash unit with an AM/FM stereo entertainment radio and LED channel readout. Price $2.00. Address: Royce Electronics Corp., 1746 Levee Rd., North Kansas City, MO 64116.

AMATEUR RADIO CATALOG

Hamtronics, Inc. offers an expanded 24-page version of its VHF and UHF Communications Modules and Accessories Catalog. Products featured include a vhf/FM receiver kit, test probe kits, audio oscillators and a PA/preamp unit for use with 2-meter rigs. A new line of ac power supplies is described and a section on antennas, cables and connectors is included. Other products described include vhf and uhf receiver and transmitter kits, a full line of preamplifiers and various adaptors. Send a self-addressed-stamped envelope to Hamtronics, Inc., 182 Belmont Rd., Rochester, NY 14612.

SANKEN AMPLIFIER APPLICATION NOTES

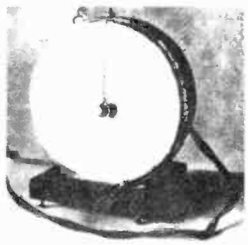
Application notes on the Sanken series S1-1000G hybrid audio power amplifiers are available from Energy Electronic Products. The 4-page flyer provides power derating information, terminal assignments and recommended connections for each amplifier in the series, with a selection of graphs, schematics and outline drawings. A table of technical specifications is also included. Address: Energy Electronic Products Corp., 6060 Manchester Ave., Los Angeles, CA 90045.

news HIGHLIGHTS

Silent Alarm for Automobiles

Said to be the only silent alarm available to prevent motor-vehicle larceny and theft, the "Page Alert System" (Torrance, CA) transmits a coded radio signal from a transmitter in the vehicle to a compact, personal pocket pager in the event theft is attempted. The signal is reported to beep its warning more than 1200 feet, both indoors and outdoors. The person carrying the pager can then make a "crime in progress" call to the police.

100 Candles for Mike



The 100th anniversary of the invention of the microphone was marked in 1977. The inventor, Emile Berliner, a 25-year-old immigrant from Germany, created the microphone in an attempt to invent an improved telephone. Introduced on March 4, 1877, the mike made voice and music broadcasting, and electrical recording a possibility. The photo shows the original microphone positioned above the telephone transmitter included in the Berliner Caveat of April 14. The telephone transmitter, forerunner of all talking pieces used in telephones today, was later acquired by the Bell System when a mouthpiece was added. *(Photo from Oliver Berliner collection.)*

Voice System Opens Doors

On the basis that no two voices are exactly alike, a new system of "people recognition" has been developed by Air Force Systems Command's Rome Air Development Center (RADC). The computerized "Voice Verification System" will be used to control entry into "secure" or controlled-access areas. Voices are entered into the computer's memory by recording four preselected phrases. Later, to get into a limited-access area, an ID number is entered with a card or a keyboard, telling the computer to go to a particular voice record. The computer asks the person to repeat one of the four phrases. If there is a match, the door opens; if not, the computer asks for another phrase. In operational tests, the system has been more than 99 percent accurate.

Low-Cost Solar Water-Heating Panels

Designed for the energy-conscious homebuilder, experimenter and hobbyist, a new low-cost solar water-heating panel from Edmund Scientific has a modular design for easy installation. Weighing 11 pounds when empty, 13 when full, the panels, measuring 30″ × 30″ × 5″, can each provide up to 1000 BTU per hour. The panel features a preformed, closed-cell urethane base, a plastic cover with ultraviolet inhibitors, and a polyurethane solar-energy absorber with integral channels for uniform water flow. Each panel is $34.95.

9111 Dialer OK'd by FCC

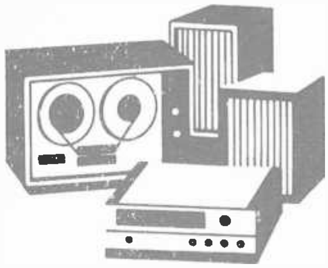
The FCC has certified the Conrac 9111 dialer for connection to phone company lines without a coupler. The 9111 dials telephone numbers for police, fire, medical, or other emergencies, and delivers a voice message from a prerecorded tape. A telephone RJ31K jack must be installed by the phone company. When requesting installation of the jack, the installer must give the phone company the FCC number (AE598C-62833-AL-R) and the ringer equivalent—0.0B.

User Participation

According to RCA Consumer Electronics Division, the $9 billion consumer electronics industry is slated to move into new product applications that permit the user to be an active participant rather than a passive observer. A wider variety of interactive devices will result as people change the way they buy and use the industry's products and services, according to a company spokesman. Television is expected to be greatly expanded to provide more emphasis on home education and management as new devices become available for use with the TV receiver. Also foreseen is a raft of new electronic products, including an SOS system for fire, smoke, and intrusion devices; widespread use of the picture telephone; home TV systems with built-in video game capability and video record/playback; wristwatches that electronically read out the time, date, temperature, and blood pressure; and a wrist radio using microelectronics and satellite techniques which could be used for electronic voting, census taking, civil defense, medical monitoring, and instant communications with police and other security agencies.

Japanese To Share FCC Testing

Japan laboratories will be doing a share of the testing of new CB radios manufactured in that country. Under a recent agreement with the Federal Communications Commission, Japanese manufacturers will submit model test data and samples to the Ministry of International Trade and Industry (MITI), which will forward results and samples to an independent Japan testing laboratory. These results will then be sent to the FCC for the final decision on type acceptance. The new program is not mandatory; Japanese manufacturers with contracts with U.S. distributors have the option of submitting models to the FCC lab. It is hoped that the new program will lighten the FCC workload, enabling it to focus on other areas such as off-the-shelf testing of CB radios and video games. Of the projected 10 million CB radios expected to be sold in the U.S. this year, 90 percent will have been manufactured in the Far East.



Stereo Scene

By Ralph Hodges

EXPANSIVELY SPEAKING

AN EXPANDER, like a compressor, is an amplifier whose gain changes with a change in input voltage. High voltage means high gain; low voltage, low (even negative) gain; and medium voltage, something like unity gain. Companders (compressors used in tandem with complementary expanders) are the bases for today's most popular noise-reduction systems. But expanders used by themselves also present appealing possibilities, or so say several consumer manufacturers. To wit: the signal coming out of them has a greater dynamic range than the signal that went in. Therefore, if the everyday recordings you play, have restricted dynamics for one reason or another, an expander can enhance their sound.

This is a possibility, but of the consumer-type expanders I've heard at any length, virtually all of them have not been able to avoid being "caught out" on some piece of program material or other. Being "caught out" means sounding somehow unnatural, calling attention to the processing behind the scenes.

As a first example, there is the "zoom lens" effect. This is prone to occur when the instrumental backup on a recording hits a sudden, mighty crash, calling upon the expander for a big boost in gain. This boost cannot be limited to only those instruments going "crash," however. *Everything* gets boosted, including the lead vocalist(s), who may thereupon seem to lurch forward into the room at you—an unsettling experience under the best of circumstances and a positive panic if you happen to be listening to "Kiss."

A related phenomenon is the "HOP-pitty-HOP-pitty-HOP-pitty" that takes place when some hearty, repetitive thud from the rhythm section modulates all the rest of the instruments in loudness according to its own beat.

Another anomaly is "ambiance truncation." As you're no doubt aware, the usual expander expands both upward and downward, making loud sounds louder and soft sounds softer. To an expander, the decay of reverberation following a big orchestral moment looks like a decrescendo, and its tendency is to make that decrescendo more abrupt and extreme, thereby abbreviating the pleasant afterglow resulting from natural reverberation.

A semi-satisfactory cure for this, and for the "HOP-pitties," consists of extending the decay time of the expander, so that the device remains in a "boost" condition (once it has been put there by the program material) for an artificially long time. This should not be overdone, however. There are antiphonal moments in symphonic music when a huge blast from the full orchestra is quickly "answered" by, for example, the delicate tinkle of a triangle—which won't be so delicate if the expander stands ready to slap a big boost on it. And there are always a few records in which the first-desk trumpet, having blown himself purple in the face for a stunning climax, cannot manage to suppress a cough as the last note dies away. A strategically located blemish on the record surface will have a similarly shattering effect when the expander boosts it up out of all normal proportions.

These problems, and others, are no mystery to expander manufacturers, who usually juggle attack and decay characteristics for the best possible effect with the greatest number of recordings. Even so, the tasteful user often finds he can get away with only mild degrees of expansion (low expansion coefficients), and he may get to the point where he finds it necessary to readjust the device for every record. At least one expander comes into operation only at the extremes of loud and soft, which seems to make adjustment less critical, but which also results in a rather subtle effect—or, indeed, no effect at all—much of the time.

A Multi-Band Expander. The compander noise-reduction systems share a few (but by no means all) of these unwelcome side effects with straightforward expanders. One reasonably effective way around them has been to operate the compander in separate, independently processed frequency bands, a la the Dolby A-type system. In particular, this scheme is accepted as being an effective remedy for so-called noise "pumping" or "breathing." Such "pumping" takes place when an expander boosts both a solo string bass on a recording *and* the tape or disc noise—inevitable if the expander works in only one full-range frequency band. But if there are separate, strategically chosen frequency bands, the bass can be confined to entirely separate low-frequency circuits, and be processed without any great effect on higher frequencies.

In straight expander applications, multi-band operation has other theoretical advantages. The "zoom lens" effect may be avoidable if the instruments prompting the expansion boost lie outside the frequency band controlling the vocalist. Low-frequency bands can be designed with a long decay time, high-frequency bands with a rapid one, which might conceivably improve the subjective handling of reverberation.

The dbx Model 3BX is a multi-band expander—the first I know of to become available to consumers for this application. The configuration chosen is three bands per channel. (It is a stereo device.) I have been giving a 3BX the works now for several weeks, and although prior experience has made me less than a fan of this kind of signal processing (a view not necessarily shared by others, admittedly), I think the 3BX shows that real progress is possible. The expected side effects and anomalies seem to be avoided much more consistently than I'd have believed possible with this (after all) rather simple elaboration of expansion techniques. Even when they could be detected, they never absolutely "rang false." Consequently, for much recorded material, I could use the full degree of expansion available (1.5 to 1) without distress (although for recordings already exhibiting satisfactory dynamics this is probably too much). Gratifyingly, the 3BX does not "sound" like an expander to me. For much of the time it *does* sound like a very effective noise-reduction system as (for quieter passages) the higher-frequency bands drop to very low gain.

The unit's front panel has three rows of LED's (ten per row) corresponding to its three bands, plus a calibrated expansion-coefficient control and another slide

Americans have been using Motorola 2-way radios to find campsites for years.

It's a fact that the people who first put radio on wheels also made the first radio on wheels on the moon.

But it's not surprising.

Because Motorola® makes more radios for police, firemen, taxis, and lunar rovers than anybody.

And now Motorola makes a 40-Channel CB radio that shares much more than a name with our professional 2-way radios.

The clean, uncluttered lines of the Motorola CB, for instance.

Features that many manufacturers leave on the outside of their sets (or don't offer at all) are built into a Motorola CB.

Gain control, noise limiting, audio compression, even a TV interference filter are built-in, fully automatic circuits that actually make communication better.

And operation easier.

A digital phase lock loop synthesizer provides precise tuning (automatically, of course).

A professional-quality 3½-inch top-fire speaker gives the Motorola CB an audio quality that must be heard to be fully appreciated.

And every Motorola CB gives you the added advantage of a power mic that doesn't need batteries. That doesn't cost 50 bucks extra.

The Motorola 40-Channel CB radio.

We believe it's the most sensibly engineered CB radio on the market. We believe it will deliver years of service at a level of performance few could match.

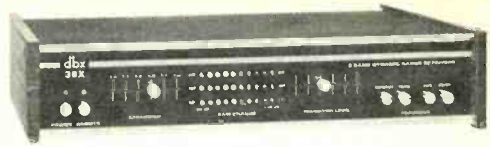
Put a Motorola CB radio under your dash and you'll believe, too.

CIRCLE NO. 35 ON FREE INFORMATION CARD

Motorola CB

From the voice of experience in 2-way radio.

To find the dealer nearest you, write: Customer Relations Manager, Motorola Inc., Automotive Products Division, 1299 East Algonquin Rd., Schaumburg, Illinois 60196.



The dbx 3BX, showing the three rows of LED indicators.

pot to set overall operating level. This last is adusted so the recording's mean levels light the LED's near the center of their respective rows. When this is done, the mean levels will undergo no expansion; higher levels will be expanded upward (boosted) and lower levels downward. The LED's wink up and down to show the degree as well as the direction of the expansion.

The dbx manual does not specify the bands of operation or the attack and decay characteristics chosen for each (it does suggest that they are appropriately different, however). I tried to get some sense of these time constants by watching the LED's, but failed.

In my view, the 3BX had one persistent fault (an effect that must be evaluated by each individual user): it functioned as a sibilance enhancer on many vocal recordings. Sibilance can be very intense on both tape and disc recordings, sometimes exceeding the level of any other material at isolated moments. Many phono cartridges have trouble with it, and may mistrace or mistrack in such a way as to accentuate it. On numerous occasions, I saw the LED's for the 3BX's high-frequency band really take off in the presence of loud "ssss" sounds, while the rest of the display remained comparatively sedate. Usually this was accompanied by a really piercing "spit" of sibilance, although the effect was notably cleaner and hence much less annoying on some recordings (the generally good ones) than on others. Discrete record noises (scratches, etc.) were enhanced in the same way. I wonder if the high-frequency band's operation could be modified or disabled (by a switch) to eliminate this minor annoyance when desired without severely compromising the processor's other good characteristics.

Phase Coherency. A few weeks ago the first "phase-coherent" speaker system I've managed to lay hands on appeared at the doorstep. A phase-coherent loudspeaker reputedly has the ability of regulating phase and arrival-time-at-listener characteristics between drivers to the point where complex waveforms actually arrive at the listener's ear—or, in this context, at a measuring microphone—with a recognizable shape when viewed on an oscilloscope. Usually this is accomplished by staggering the drivers so they are at appropriate different distances from the listener, and then designing the crossover network to complement this physical arrangement. Superior clarity and resolution of musical detail (as well as superior stereo imaging) are attributed to these loudspeaker designs, in one degree or another, by their manufacturers. Naturally, I have been curious to learn if these claims are borne out.

As for this first arrival, the highly praised B&W DM6 from England, results are inconclusive at present. The system *will* reproduce a recognizable 1-kHz square wave—something the comparison speaker system (a multi-directional radiator with no attention paid to time/phase relationships) cannot begin to do. (Actually, though, the comparison speaker *did* manage to put out something vaguely like a square wave when the pickup microphone was located at an improbable angle off axis. I discovered this "magic" location purely by accident. But when I went back later to confirm the phenomenon, I was unable to find the right spot again.)

The DM6 does not produce a very pretty square wave (sorry, I am not equipped to take scope photos), and at the measuring distance of approximately six feet a microphone shift of two inches off axis laterally or vertically alters it beyond recognition. But, evidently, the feat can be accomplished. Of course, for a listener six feet away, only one ear at a time can enjoy the phase-coherent square wave; the other will be too far off the optimum axis.

Staggered array of DM6 is intended to ensure simultaneous arrivals at the ear from all three drivers.

More important is how it sounds. In direct comparison with the totally nonphased system (which is however regarded as an excellent speaker) other listeners and I have heard no differences that we aren't inclined to attribute to very easily measurable frequency-response factors. We have used recorded material that involved both the most complex and the simplest arrays of microphones and associated equipment, including tapes we made. We also used spoken voice miked live from an adjoining room. At times there was an impression of greater unspecific space or "air" around the nonphased multi-directional pair, but otherwise the stereo imaging (in terms of localization and depth) was excellent and virtually identical from both systems. This came as a surprise; all of us were expecting some capability in the phase-coherent pair for added sharpness of localization or more precise depth information. But so far, any differences, qualitative or quantitative, have eluded us. We'll see what further developments bring. ◇

Julian Hirsch Audio Reports

HIRSCH/HOUCK LABORATORIES

SPEAKER SYSTEM MEASUREMENTS—IS PHASE RESPONSE IMPORTANT?

For many years, attempts have been made to identify the parameters that determine the sound of a speaker system. Some parameters, such as frequency response, appear to be obvious, but if given a little thought, they are less clear than those for other components in a sound system. Unlike a tuner or amplifier, for example, a speaker system does not have definite input and output ports. The input is simple enough—a pair of terminals that present a rather complex impedance load to the signal source. Since amplifiers are constant-voltage sources, the impedance of a speaker system can be assigned a secondary place in the hierarchy of the parameters that affect the sound.

The "output" of a speaker system is even more complex. There is no single "output" from a speaker system that uniquely determines its sound. This is perhaps the major problem for anyone who wishes to measure speaker system performance objectively and meaningfully. Some people who test speaker systems consider the acoustic pressure generated to be the system's output. This raises the question about how this pressure is to be measured. In general, the pressure measurement is an unpredictable function of the distance and direction between the speaker system and the measuring microphone. Furthermore, in any room that does not absorb all the acoustic energy impinging on its boundaries (this is any room except a properly designed and constructed anechoic chamber), some energy will reach the microphone by reflection. The reflected energy cancels or adds to the direct-energy component and causes appreciable response fluctuations as the frequency is changed. These are independent of the response characteristics of the speaker itself.

Anechoic measurements can produce impressive curves that tell us little about how the speaker system actually sounds. In the real world, we hear a composite of the direct-energy output from a speaker system and a multitude of reflections from the room surfaces. This sound is closely related to the total acoustical output power delivered by the speaker system to the volume of air that loads its cones. The power output is an integration of the square of the sound pressure level (SPL) over the spherical boundary, or fraction thereof, into which the speaker system faces. It can be measured in a cumbersome point-by-point manner and processed by a computer. Fortunately, it is also possible to measure the total output power of a speaker system directly in a reverberant chamber. This is a room with hard, nonparallel surfaces that absorb almost no sound energy.

The reverberant response of a speaker system is close to being the analog of its perceived (subjective) frequency response. It is not exact, but almost nothing in the entire process of sound reproduction is exact. Since a reverberant chamber is at least as large and expensive as an anechoic chamber, it is a tool of a well-equipped speaker design laboratory and is unlikely to be included in the facilities of even an up-to-date private laboratory. However, even a normally furnished listening room has many of the properties of a reverberant chamber.

If one remains beyond a certain distance from the speaker system, the SPL varies little throughout a large portion of the room. When this condition is satisfied, one is said to be in the "reverberant field" of the room. Apart from any theoretical compromises involved in measuring speaker system response in the reverberant field of a normal room, the room has the virtue of being a realistic environment for speaker system testing. It is in this environment that the speaker system will be used and listened to, and it makes sense to evaluate it under these conditions. In our room, the measured response over most of the frequency range from several hundred hertz to 15,000 Hz varies by only a couple of decibels with large changes in the position of the microphone or speaker with the two at least 10 ft (3 m) apart.

In either a reverberant or a quasi-reverberant measurement, it usually is impractical to go below about 500 Hz because of standing waves in the room. (Anechoic chambers also have low-frequency limitations, unless they are prohibitively large.) Thus, it is necessary to measure the woofer's response with a microphone placed as close as possible to the cone. This effectively removes the room from the measurement environment. Splicing this curve to the one obtained in the reverberant field, we obtain a composite curve that, although not completely a property of the speaker, is nevertheless a good indicator of how it will perform in a real listening room. The larger trends in energy response versus frequency can be seen easily and usually correlate well with listening tests.

There is much more to the process, but the preceding is a simplified description of the "frequency response" measurements made by Hirsch-Houck Laboratories on speaker systems. The result is not *the* fre-

SBE
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quency response; it could more accurately be described as *a* frequency response, one of an infinite number of possible responses.

Now that we have dealt with frequency response, what about *phase response*? To preserve the shape of a complex waveform, all frequency components must be maintained in their correct amplitude *and* phase relationships. Reversing the phase of one harmonic in a square-wave signal, for example, can completely change the shape of the "square" wave, even though a spectrum analysis of the signal will reveal no change. If preservation of the waveform is important to accurate sound reproduction, a linear phase speaker system would appear to be a necessity. The phase shift of the output of such a speaker system, relative to the input signal, would increase in proportion to frequency so that all signals within the audio range would be propagated without any differential time delay. A square-wave input signal would be recoverable as an acoustic square wave, subject only to the natural bandwidth limitations of a speaker system.

The need for, or the desirability of, a linear phase characteristic has a certain logical appeal. It is difficult to imagine that phase shifts that can totally alter the shape of a signal waveform cannot be heard. Nevertheless, many experimenters over the years have come to this conclusion. On the other hand, it is possible to prove—or disprove—just about anything by establishing the appropriate experimental conditions. Recently, there have been some indications that extremely small phase shifts can be heard under certain narrowly defined circumstances. We prefer to remain neutral about this at this time, but it might be instructive to relate a personal experience we had recently when we visited the Osaka headquarters of Matsushita Electric, manufacturers of the Technics by Panasonic high-fidelity product line.

Technics has made a determined effort to remove speaker system phase shifts from the high-fidelity reproduction equation. At the company's speaker laboratory, a linear phase speaker system, similar to the Model SB-6000A, reviewed in this issue, was placed in a large anechoic chamber and driven by a square-wave signal. The output of a microphone placed several feet in front of the speaker system, was viewed on an oscilloscope, where it could be seen to be an excellent square wave. This was convincing evidence that Technics had achieved a linear phase shift, or negligible time delay distortion. During the demonstration, the tweeter was physically moved back and forth as we listened inside the chamber to the square-wave output signal. As expected, the waveform on the oscilloscope underwent rather drastic changes, but we could hear no significant differences in the character of the sound. The key word is *significant,* since any changes that took place were of the same magnitude that resulted from a slight head movement or a shift of a few inches in listening position.

Our tests of the Technics Model SB-6000A, using the methods described and a number of others, revealed that it is a very fine speaker system in every respect. The obvious question is: does the phase linearity of the speaker system account for its excellence, at least in part? Or is it simply a good speaker system, for reasons not directly related to its phase characteristics? Well, we have tested and "lived with" a couple of other "linear phase" speaker systems that use somewhat different design principles. In side-by-side comparisons, the Model SB-6000A, in our judgment, was far superior to the others. On the other hand, we have conventionally designed speaker systems that make no claim to phase linearity and are roughly equivalent in accuracy to the Model SB-6000A in the same comparison. They do not sound identical to the Model SB-6000A (no two speaker systems sound alike) but they are of comparable quality—*without* phase linearity—though those A–B'd were costlier.

Maybe a good speaker system with phase linearity is better than a good speaker system without it, but returns in this controversy are not yet counted. As always, we recommend that the consumer be more concerned with how *well* a product performs, rather than with its special or unique design principles. After all, we do not listen to principles.

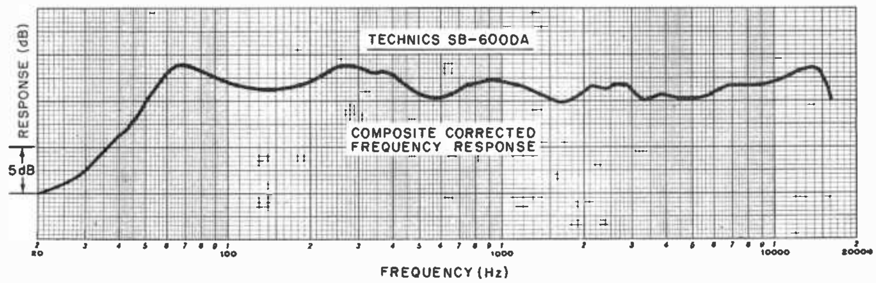
TECHNICS MODEL SB-6000A LINEAR PHASE SPEAKER SYSTEM

Innovative design provides top performance and high efficiency.

HIRSCH-HOUCK LABS REPORT

When speaker phase response began to be mentioned in the technical press a few years ago, it was principally to point out how inferior available speaker system designs were in this respect. Now we are beginning to see speaker systems designed to dramatically reduce unwanted phase shifts that can seriously distort waveforms. A fine example of the new linear phase design is the Technics by Panasonic Model SB-6000A.

The Model SB-6000A is a two-way system that contains a 12" (30-cm) woofer and a 1¼" (3.2-cm) dome tweeter. The crossover frequency is at 1800 Hz. The enclosure features a bass-reflex design, with a ducted port near the top of the cabinet. The relatively high-efficiency, 6-ohm speaker system is rated to produce a 91-dB SPL at a 1-meter distance with 1 watt of driving power.



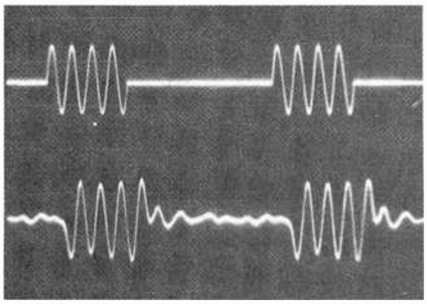
Composite corrected frequency response of Technics SB-6000A speaker.

Additionally, it is rated to handle up to 100 watts of program power without risking voice-coil burnout or mechanical damage to the driver. (A graph that accompanies the installation instructions illustrates the maximum permissible power as a function of frequency and duty cycle.) The frequency response of the system is stated as 39 to 22,000 Hz, based on the output at the limit frequencies being 10 dB below the average midrange level.

The speaker system measures 33¼"H × 16¾"W × 13⅜"D (84.6 × 42.5 × 34 cm) and weighs about 55 lb (25 kg). The national advertised value of the system is $299.95.

General Description. Technics has designed the speaker system so that the woofer and tweeter are as close together as possible. To accomplish this, the woofer is mounted near the top of the ported enclosure, 21" (53.3 cm) above floor level, and the tweeter employs a square magnet assembly. The tweeter is mounted outside the main enclosure that houses the woofer, directly above the woofer and set back from the front of the main enclosure. Also on top of the enclosure are the speaker-hookup terminals, a continuously variable tweeter control, and a graph that shows the effect of the level control on the system's frequency response. An easily removable black fabric grille and top cover hide the drivers from view.

All exterior surfaces of the speaker system are finished in flat black, except for two vertical metal rods at the front corners of the main cabinet.



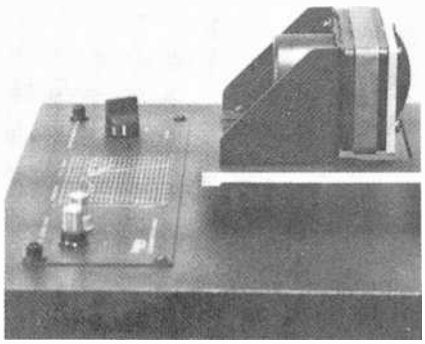
Tone-burst response at 1000 Hz.

The linear phase response was achieved by combining a specially designed crossover network with drivers that have a linear phase reponse within their individual operating frequency ranges and by locating the tweeter behind the woofer's front surface where the path lengths of their respective outputs are identical.

Laboratory Measurements. Since we did not have the facilities to check the claimed linear phase response of the speaker system, we followed our standard loudspeaker test procedure. The frequency response, measured in a normally "live" room, was remarkably free from the peaks and dips typically found when measuring speaker systems under these conditions. From 1000 Hz upward, virtually no smoothing was required to derive our averaged response curve from individual measurements of the two speaker systems in their normal stereo locations, with a single microphone position near the rear of the room.

The woofer response was measured with a close microphone spacing to eliminate room effects, and was combined with the response measured at the bass reflex port to obtain the system response below a few hundred hertz. Splicing this to our high-frequency curve, we came up with an impressively flat composite frequency response that was within ± 2 dB from 50 to 16,000 Hz (the effective upper limit of our microphone's calibration). Over much of this range, the response was at least as flat as the resolution of our measurement system, or within ± 1 dB from 450 to 10,000 Hz. There was a slight rise in output, of 2 to 3 dB, in the 200-to-400-Hz octave and a bass resonance rise of about the same amplitude at about 70 Hz. The bass output was 10 dB below the average midrange level at 27 Hz. (This would be strongly affected by room dimensions and speaker placement in any specific installation.)

These measurements were made with the tweeter level control set to maximum, which was the setting for a recommended "flat" response. When we turned down the tweeter level control the output was cut above 1700 Hz with no effect whatever at lower frequencies. This contrasts sharply with many speaker-balance adjustment schemes in which system response is affected at frequencies well removed from the nominal crossover points. The bass distortion was measured with close microphone spacing at frequencies of 100 Hz and below. Tests were made with constant drive levels corresponding to 1 watt and 10 watts input and with the drive adusted to maintain a 90-dB SPL at a distance of 1 meter from the speaker. Again, the speaker system was somewhat unusual in that the *shape* of its distortion curve and its "break" point at about 35 Hz did not change significantly with power. Of course, the actual distortion at each test frequency was higher with 10 watts input than with 1 watt. The 90-dB SPL curve fell approximately midway between the two curves. The actual distortion at 1 watt was less than 1% down to 45 Hz and rose to 4% at 30 Hz and 16% at 25 Hz. These can be considered exceptionally low distortion figures for any speaker system.



Top of system showing response curves, terminals, and controls.

Although we could not check phase linearity (for instance, by square-wave measurements) in a "live" environment, we found that the tone-burst response of the system was considerably better than average at all frequencies. In fact, it changed little with frequency. The 1000-Hz burst response photo is typical of what we observed. The system impedance reached a minimum of 5 ohms between 1000 and 6000 Hz and a maximum of 50 ohms at the 58-Hz bass resonance. The speaker, as claimed, was quite efficient, and delivered a 91.5 dB SPL at 1 meter when driven with 1 watt random noise in the octave centered at 1000 Hz.

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User Comment. It was obvious from our measurements that the Technics Model SB-6000A must rank as a fine speaker system, excelling in just about every characteristic for which we were able to test. However, the proof of a system's performance is in the listening, and we performed the simulated "live-versus-recorded" test with considerable interest.

There were no surprises here. Side-by-side with our "live" music source, a loudspeaker reproducing wide-range music program material, the Model SB-6000A matched the "live" sound (recorded anechoically on the second track of the 15-ips half-track tape carrying the original program) with above-average accuracy. The midrange and highs were virtually perfect, with the latter being dispersed more effectively than by most other dome-type radiators we have heard. In the lower midrange, there was a slight "warmth" which we attribute to the 300-Hz rise in the response curve.

Playing other types of program material, the system displayed the same qualities, with the addition of a very potent bass output. (The live-versus-recorded test is limited to frequencies above 200 Hz.) We located the speaker system well away from the room corners, but within 6" (15.2 cm) of a wall, with good sound balance.

We are in no position to judge how much of the system's excellent sound quality comes from its linear phase characteristics and how much from its simply being a very good speaker system. Of course, this is not an important consideration in the evaluation of a speaker system. What *is* important is the evident fact that this is one of the better sounding speaker systems we have heard in a long time.

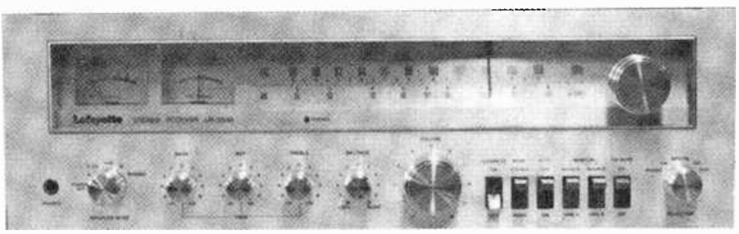
The high efficiency of the Model SB-6000A is another "plus," since it can deliver an impressive amount of clean, undistorted sound when driven by a modestly powered amplifier. In spite of this, it was able to absorb most of the power available from a 200-watt/channel amplifier without audible distress or damage to the drivers.

Styling, of course, is a purely subjective matter. The appearance of the Technics SB-6000A is not conventional, and no doubt it would be aesthetically incompatible with some home decor. But we found its external design to be both attractive and functional. It would appear that Technics has laid to rest the notion that Japanese speaker systems do not match the taste of the American audiophile. You just have to listen to the Model SB-6000A speaker system to shatter this mistaken belief.

CIRCLE NO. 101 ON FREE INFORMATION CARD

LAFAYETTE MODEL LR-3030 AM/STEREO FM RECEIVER

Delivers 30 watts/channel at moderate price.



HIRSCH-HOUCK LABS REPORT

Lafayette Radio Electronics' Model LR-3030 AM/stereo FM receiver is representative in appearance of the company's redesigned 1977 line. It is rated to deliver 30 watts/channel into 8-ohm loads at 1000 Hz with no more than 0.5% total harmonic distortion (THD).

The receiver comes with a metal dust cover and wood-finished side panels. It measures 19 3/4"W × 14"D × 6½"H (50.2 × 35.6 × 16.5 cm) and weighs 24 lb (11 kg). Price is $299.95.

General Description. Instead of the usual "blackout" dial window, the tuning scales of this receiver are always visible through a clear window. To the left of the scales are two large illuminated meters that indicate signal strength on AM and FM and center-channel tuning on FM only. Below the dial scales is a red LED that comes on when a stereo FM broadcast is being received.

Across the bottom of the front panel, from left to right, are a headphone jack, combined speaker selector and power switch, tone controls (bass, midrange, treble), and balance control. The three tone controls are each detented at 11 positions, while the balance control is detented at its center position. The speaker selector switch can be used to connect either, both, or neither of two pairs of speaker systems to the outputs of the power stages. (If the B pair of speaker systems is located toward the rear of the listening room, a 4 CHANNEL position on the speaker selector switch allows them to be driven with difference channel material to simulate 4-channel sound via the ambience-recovery principle.)

The large VOLUME control knob can be set to any one of 40 detented positions. The input selector, located at the far right of the front panel, has positions for PHONO, AUX, FM, and FM with an MPX FILTER that partially blends the higher frequencies to reduce noise on weak stereo FM signals. Six lever switches control the loudness compensation, stereo/mono mode selection, high-cut filter in/out, FM muting, and tape monitoring (the last for two decks).

On the rear apron of the receiver are insulated spring clips for speaker system hookups and binding-post terminals for 300- and 75-ohm FM antennas and an AM wire antenna. There is also a pivoted AM ferrite-rod antenna. A switch is provided for setting the sensitivity of the phono inputs for high- and low-output magnetic cartridges. Each speaker output is separately fused, and there is a single unswitched ac outlet.

The receiver employs 11 IC's. The power output stages are hybrid IC modules, and the phono preamplifiers use op-amps. The tuner section contains an IC that functions as an FM i-f amplifier, limiter, and detector, another IC for the multiplex demodulator, and a third IC for the AM tuner section. In essence, discrete solid-state components are used only for the FM front end, audio tone control amplifier, and power supply regulator sections.

Laboratory Measurements. To bring the receiver to operating temperature, we ran it for an hour at one-third power and five minutes at full power. At this point, the audio amplifier clipped just short of 40 watts/channel at 1000 Hz into 8-ohm loads. The power into 4- and 16-ohm loads was 48 and 26 watts/channel, respectively. The con-

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Inside of receiver showing hybrid IC's for output stages.

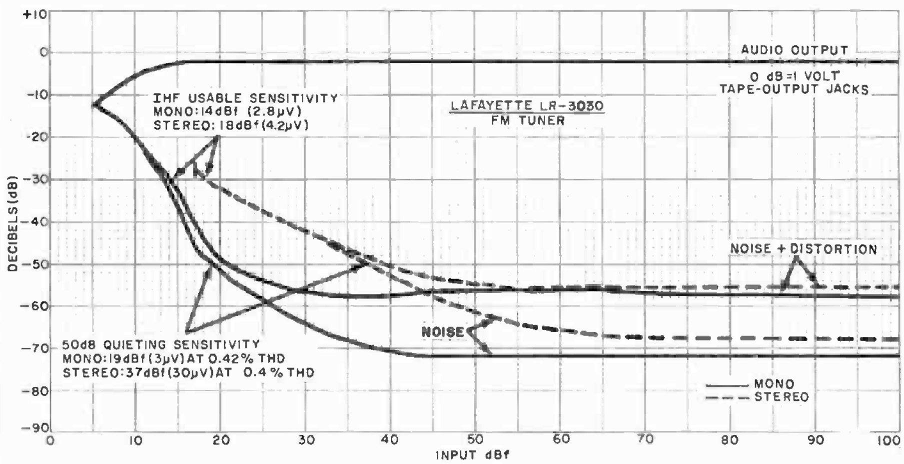
servatism of Lafayette's ratings can be appreciated from the fact that the 1000-Hz THD was less than 0.01% between 0.1 and 1 watt output and a smooth increase to only 0.027% at 35 watts output. At the clipping point of 40 watts output, the THD measured only 0.1%.

The IM distortion measured between 0.023% and 0.073% from 0.1 to 35 watts and 0.1% at 40 watts. At the rated 30 watt output, the distortion was about 0.02% from 20 to 20,000 Hz. It increased to about 0.06% in the octave between 10,000 and 20,000 Hz. At half power, it was about the same, and at one-tenth power, the only difference was a slight increase in distortion at low frequencies (to 0.05% at 20 Hz).

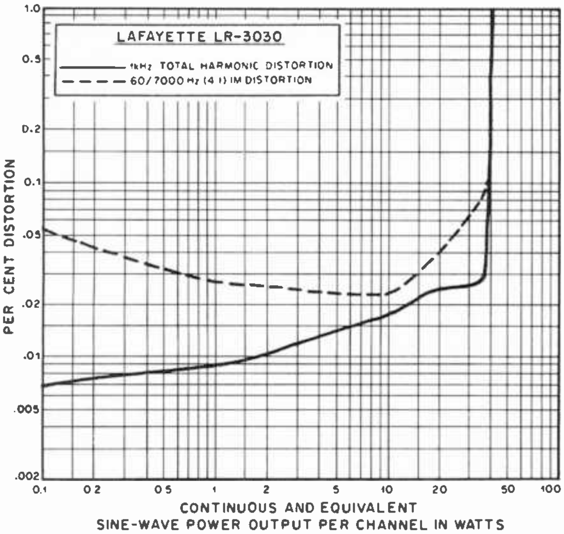
To produce a reference 10-watt output, the AUX input required an 80-mV signal. The S/N ratio was very good here, measuring 82 dB. Through the PHONO inputs, the sensitivity was 1.9 or 3.8 mV, depending on the setting of the rear-panel sensitivity switch. The S/N here was 72.5 dB. The phono overload capability was excellent, especially for a receiver in the Model LR-3030's price range. Clipping occurred at 265 and 530 mV with the sensitivity switch set to its alternate positions.

The bass tone control's turnover frequency slid between 100 and 300 Hz as the control was advanced. The treble response curves were hinged at about 3000 Hz. The midrange control affected a broad range of frequencies, from approximately 300 to 4000 Hz and had a maximum range of ±6 dB.

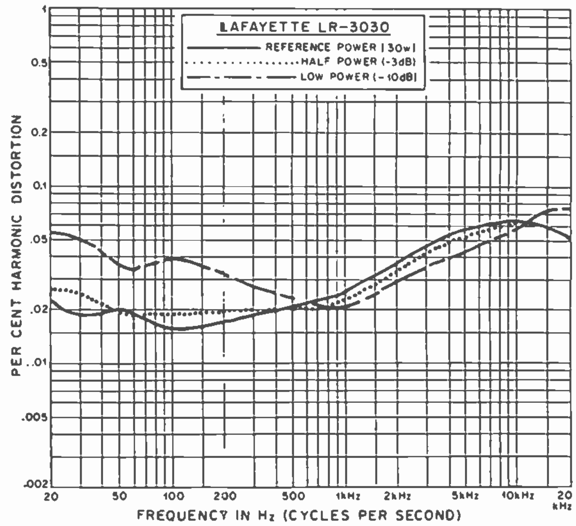
The loudness compensation boosted both low and high frequencies relative to the midrange as the volume was reduced. The high-cut filter had a 6-dB/



Noise and sensitivity curves for FM section of Lafayette receiver.



Total harmonic distortion and 60/7000-Hz distortion.



Harmonic distortion at three power levels.

octave slope, with the −3-dB response point at 4000 Hz. Its effect on the frequency response was little different from that of the treble tone control. The RIAA phono equalization was very accurate, varying less than ±0.5 dB from 20 to 20,000 Hz. Apparently because of the op amp configuration of the phono preamplifiers, which completely isolates the signal input circuits from the feedback equalization components, the phono response was totally unaffected by cartridge inductance.

The FM tuner section had an IHF sensitivity of 14 dBf (2.8 μV) in mono and 18 dBf (4.2 μV) stereo. The 50-dB quieting sensitivity was 19 dBf (5 μV) in mono, with 0.42% distortion. In stereo, it was 37 dBf (38 μV), with the same distortion level. The ultimate quieting (S/N) was 72 dB in mono and 68 dB in stereo. FM distortion was very low, measuring 0.15% in mono and 0.17% in stereo. The stereo distortion with L − R modulation was 0.85% at 100 Hz, 0.32% at 1000 Hz, and 0.14% at 6000 Hz.

Capture ratio was an excellent 1.25 dB at 65 dBf (1000 μV) and 1.1 dB at 45 dBf (100 μV). The AM rejection at these levels was 59 dB and 62 dB, respectively. Image rejection at 98 MHz was 55 dB. Alternate-channel selectivity was 64.5 dB, and adjacent-channel selectivity was 7 dB. The muting and stereo switching thresholds were identical at 19 dBf (5 μV). Hum level was −67 dB.

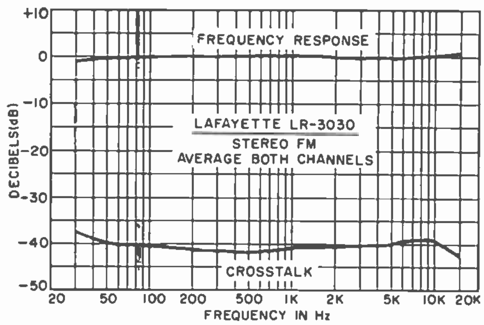
The FM frequency response was almost perfectly flat, within ±0.5 dB from 50 to 15,000 Hz. It was down only 1 dB at 30 Hz when measured at the tape recording outputs. In spite of the complete absence of any rolloff at 15,000 Hz (the usual result of the low-pass filter used to cut out pilot carrier leakage), the 19-kHz component in the audio output was an insignificant −68 dB. Stereo channel separation was unusually uniform as well as very high, measuring from 38 to 42 dB over the full 30-to-15,000-Hz range. The AM frequency response was quite restricted, being down 6 dB at 50 and 3000 Hz.

User Comment. In most cases, our measurements revealed that the receiver met or surpassed its ratings, usually by a comfortable margin. One of the few exceptions was the FM sensitivity, rated at 11.2 dBf, or 2 μV. The difference between our measurement and the rated value is insignificant, partially explainable by differences in test equipment and measurement conditions. In our view, the many other respects in which the receiver excelled more than made up for this trivial discrepancy.

Obviously, this receiver has all the qualities necessary for true high-fidelity performance. In addition, and every bit as important, it has the smooth operating "feel" that we associate with advanced (and usually expensive) components. Every control works smoothly and with a positive action. The FM muting system is one of the best we have used. (There were no noises whatsoever when tuning; we merely heard the programs coming on and going off smoothly.) The FM dial calibration was very accurate, with the linear dial calibrations spaced at 1-MHz intervals.

We did not use the 4 CHANNEL operating mode, but past experience with this type of ambience-recovery system indicates that it is the least expensive method of enhancing stereo sound quality.

Frequency response and crosstalk averaged for both channels in stereo FM.



Tape recording enthusiasts will appreciate that the monitoring switches can be set to dub from deck A to deck B, though not in the opposite direction.

In all, the LR-3030 is unequivocally a fine receiver for the money.

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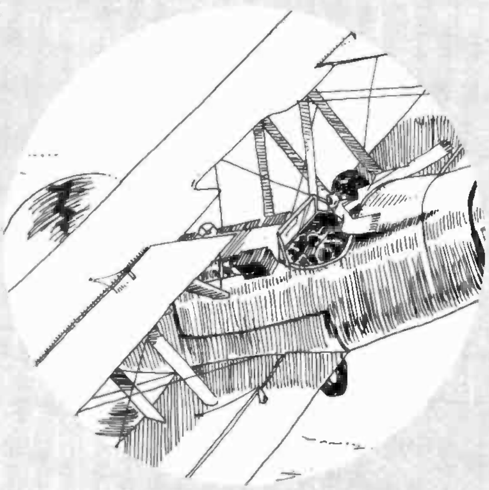
HOW TO PROGRAM CALCULATORS FOR FUN AND GAMES

FOOTBALL

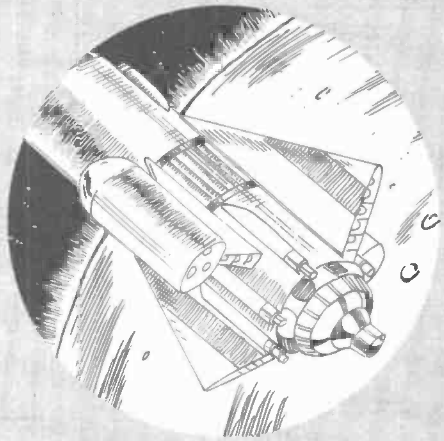
TEST YOUR ESP

BATTLE THE DIVE BOMBER



BIORHYTHM FORECAST

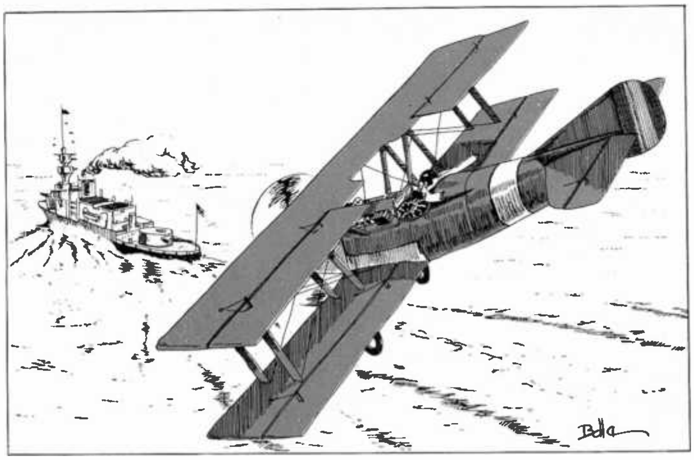
SPACE FLIGHT



BLACKJACK

WITH THE growing popularity of hand-held programmable calculators, hundreds of users are programming them to do things other than just straight mathematics. Among the more popular pastimes is to play games. Here is a collection of six reader-generated calculator programs that should keep your calculator busy for some time. Four of these are games: "Dive Bomber" has you aboard a ship trying to shoot down a dive bomber before it blows you up; "Football" has you playing the game with six basic plays and random-number control of offense and defense effectiveness; in "Blackjack," you gamble against one or more opponents; and "Space Flight" has you piloting a spacecraft between and around two planets and gives you the option of landing if you wish. The last two programs are "scientific" in nature: In "Biorhythm Forecast," you forecast the physical, emotional, and intellectual behavior of yourself or anyone else for any given day or period; and in "Test Your ESP," you have the calculator "flipping a coin" and you make guesses based on your ESP.

All the programs presented here are written in RPN specifically for the Hewlett-Packard HP-25 programmable calculator. However, if you have another make or type of programmable calculator with the necessary functions, you can rewrite the programs to suit your own particular needs.



BATTLE THE DIVE BOMBER

● In this game, the goal is to shoot down a dive bomber with antiaircraft fire before it can bomb your ship. The initial range of the plane is known to be 1000 m but its speed can only be guessed to be between 100 and 200 m/s, thanks to the random number generation of the program. To zero in on the plane range, estimates are made for firing once a second as the plane approaches and range errors are fed back. However, range error is known only to within ±10 m, which is close enough to hit the dive bomber with flak but not close enough to destroy it. This means essentially a direct hit (±3 m from the plane's center).

For the first range estimate, the average speed of 150 m/s is assumed to define a range of 850 m as shown in Fig. 1. When this range is run through the program, the calculator display will show the range error within ±10 m. This error defines the approximate true range of the plane after the first second and also defines an approximate speed. Using this new data, the approximate range at the end of the next second is found for the new range setting. Repeating this procedure, hits on the airplane will soon be made as indicated by a zero in the display. If a direct hit is made, 0.000000000 will be displayed.

Should the range close to zero, the plane's bomb will either hit the ship or, as 15% will, miss and hit the water. This probability is also controlled by a random number generator with a bias toward misses by higher speed planes. If the bombs hit the ship, the display indicates ERROR, and a miss is indicated by a 1.

Shown in Fig. 1 are each of the three possible conclusions that are reached through using the illustrated range finding technique for the first game run after storing the random number seed numbers shown. Since this seed number is stored only once per programming, the following games are controlled by the random selection of variables. The programming sequence is shown in Fig. 2 and the program-run sequence in Fig. 3.

Greater success can be achieved through more clever interpretation of error data variations and by slight variation in range once successive hits are at-

Seed number	.7	.5	.1
Initial range R_0	1000	1000	1000
Est. ΔR in 1s	150	150	150
Range setting	850	850	850
Range error	10	0*	40
True Range R_1	840	850	810
Est. ΔR in 1s, (R_0-R_1)	160	150	190
Range setting	680	700	620
Range error	10	-10	0*
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
True Range R_n	670	10	30
Est. ΔR in 1s, $(R_{n-1}-R_n)$	170	140	200
Range setting	500	0	0
Range error	00...0(1)	Error(2)	1(3)

* Plane hit
(1) Plane destroyed
(2) Ship sunk
(3) Ship missed

Fig. 1. Possible conclusions for three random seed numbers.

Registers

R_0	Random number
R_1	Empty
R_2	True range
R_3	Empty
R_4	Empty
R_5	- (Speed)
R_6	Range error
R_7	Range setting

Display Line	Key Entry	Comments
00		
01	STO 7	
02	f FIX 0	
03	EEX	
04	3	Initial range
05	STO 2	
06	g π	
07	RCL 0	
08	+	
09	5	
10	f y^x	
11	g FRAC	
12	STO 0	
13	1	
14	+	
15	EEX	
16	2	
17	X	Speed scale
18	CHS	
19	STO 5	
20	RCL 5	
21	STO + 2	
22	RCL 7	
23	RCL 2	
24	g x<0	
25	GTO 43	
26	-	
27	STO 6	Range error
28	g ABS	
29	3	
30	f x≥y	Destroyed?
31	f FIX 9	
32	RCL 6	
33	1	
34	0	
35	÷	
36	f INT	
37	1	
38	0	
39	X	
40	R/S	Result
41	STO 7	
42	GTO 20	
43	RCL 0	
44	.	
45	8	
46	5	
47	f x≥y	
48	GTO 34	Hit ship
49	1	Missed ship

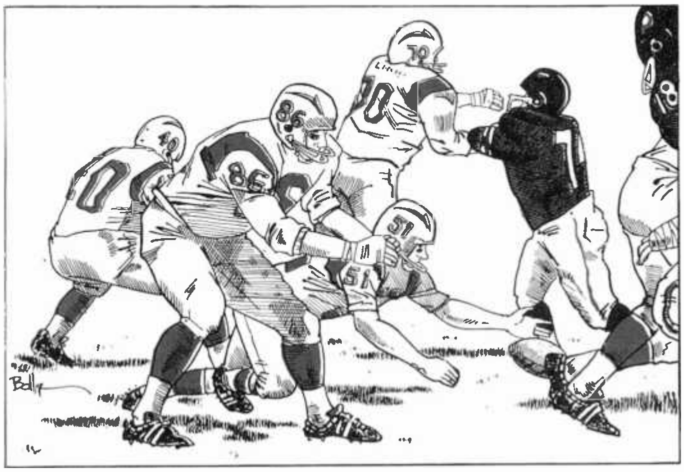
Fig. 2. Dive bomber program.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEY ENTRY	OUTPUT DATA/UNITS
1	Key in program			
2	Store random number seed	0 < n < 1	STO 0	
3	Initialize		f PRGM	
4	Key range estimate, computer range error	R	R/S	Range error
5	Repeat step 4 until conclusive result			Result
6	To start a new game, go to step 3.			

Fig. 3. Dive bomber program-run sequence.

tained. Alternately, the odds can be varied to initially get the feel of the game or to increase the challenge. The easiest to vary are the destruct radius on line 29 and the fraction of bombs that hit on lines 44 through 46. The speed scale of lines 15 and 16 and the initial range of lines 3 and 4 can also be varied but only so that these entries take two steps each in the program.

—*Jerald Graeme*



FOOTBALL

● Game rules define a field from a zero-yard line to a 100-yard line, with one player's goal at each end. For a touchdown, the ball must be moved to a position less than zero or greater than 100 as monitored by the calculator display. The team in possession is defined by a stored ID number. Six basic plays are possible: kickoff, run, pass, punt, conversion, and field goal. By skillfully mixing these plays, the best strategy can be found for a given set of stored play-effectiveness characteristics.

To begin the game, numbers are stored to set the average effectiveness of the defense, the probability of an incomplete pass, and a yardage gain multiplier. Typical numbers are in the instructions in Fig. 1. Control is also possible over the average characteristics of kicks and kickoffs with the steps noted in the program. Actual gain or loss on the play will be determined by a random number multiplier and by a second random number that is compared against the defense and pass probabilities. For the kickoff, the ball is placed on the 20 or 80 yard line by storing that number in the zero register; and the team in possession is defined by storing an ID number 1 or a −1 in the 6 register (see Fig. 2). Results of the kickoff will be displayed by an operating pause showing the gain

Display Line	Key Entry	Comments	Display Line	Key Entry	Comments
00			31	GTO 41	
01	RCL 4		32	1	
02	π		33	3	Kick
03	+		34	STO + 5	characteristics
04	e^x		35	2	
05	FRAC	1st random number	36	GTO 42	
06	RCL 3		37	RCL 4	
07	X		38	RCL 1	
08	2		39	x ≥ y	
09	−		40	GTO 43	Good defense
10	STO 5		41	4	Poor defense
11	FRAC		42	STO X 5	
12	ABS	2nd random number	43	RCL 5	
13	STO 4		44	INT	
14	x⇄y		45	Pause	Gain or loss
15	x = 0		46	RCL 6	
16	GTO 37	Run	47	X	
17	x < 0		48	STO + 0	
18	GTO 32	Kick	49	RCL 0	Yardline
19	2				
20	x = y				
21	GTO 28	Kickoff			
22	STO X 5	Pass			
23	RCL 4				
24	RCL 2				
25	x < y				
26	GTO 37	Pass complete			
27	GTO 44	Pass incomplete			
28	1				
29	1	Kickoff			
30	STO + 5	characteristics			

Registers

- R_0 Yardline
- R_1 Defense probability
- R_2 Pass incomplete probability
- R_3 Gain factor
- R_4 Random number
- R_5 Gain or loss
- R_6 Player I.D. (+1 or −1)

Fig. 1. Program for football game.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEY ENTRY
1	Key in program		
2	Set display		f FIX 0
3	Store defense probability		0.8 STO 1
4	Store pass incomplete probability		0.3 STO 2
5	Store gain factor		14 STO 3
6	Store random number seed	0 < n < 1	n STO 4
7	Store team ID	A(1)	A STO 6
8	Place ball if appropriate	B(2)	B STO 0
9	Key play code, compute gain or loss on play	C(3)	C R/S
10	Repeat 9 until ball changes hands or must be placed, then repeat Step 7 or 8.		

Fig. 2. Football program-run instructions.

1 Team's Goal Line	A	2 Play	B	3 Play	C
0	1	Kickoff or following kickoff	20 or	Kickoff	2
100	-1	beyond goal	80	Pass	1
		Conversion	10 or 90	Run	0
				Punt, conversion or field goal	-1

or loss on the play, then a stop at the resulting ball possession.

The receiving team's ID number is stored and plays are called by keying the code numbers of the instructions. This continues until a touchdown is made or possession is lost through failure to make the first-and-ten, by punt or by a field-goal attempt. Successful field goals and conversion kicks are indicated by a ball landing 15 yards inside the goal line. Progress toward a first-and-ten is monitored by the player.

Thanks to random-number influence, it is strategy that wins this game of football. Depending on player preferences, the program can be set up for a better passing game, better running game, tougher defense, etc.

—*Jerald Graeme*

BLACKJACK

● The decision-making capability of the HP-25 lends itself to solving complex algorithms that heretofore required a computer to solve. The calculator has several conditional branching instructions that allow the sequence of the program execution to be altered based on the outcome of a test on the contents in the X and Y registers. If the answer to the test is YES, the program continues sequentially downward; if NO, the program branches, bypassing the next and continuing on to the following step. This is what is done when playing "Blackjack" (or "21").

To play Blackjack, each player "draws" two or more cards, the point values of which are stored in memory. Numbered cards are worth their face values; the Jack, Queen, and King are worth 10 points each; and the Ace is scored as 1 or 11 at the player's option.

Display Line	Key Entry	Display Line	Key Entry
00		25	R↓
01	CLX	26	f FIX 0
02	STO 1	27	f PAUSE
03	STO 2	28	f PAUSE
04	R/S	29	f FIX 2
05	g x = 0	30	EEX
06	GTO 01	31	2
07	STO 0	32	÷
08	RCL 3	33	STO 5
09	g π	34	RCL 0
10	+	35	2
11	5	36	f x = y
12	f y^x	37	GTO 42
13	g FRAC	38	RCL 5
14	STO 3	39	STO + 1
15	RCL 4	40	RCL 1
16	X	41	GTO 45
17	f INT	42	RCL 5
18	1	43	STO + 2
19	f x ≥ y	44	RCL 2
20	GTO 48	45	RCL 0
21	R↓	46	+
22	RCL 7	47	GTO 04
23	f x = y	48	RCL 6
24	GTO 48	49	GTO 26

Registers

R_0	Working player's number
R_1	Score of Player 1
R_2	Score of Player 2
R_3	U_0
R_4	13
R_5	Last Card
R_6	10
R_7	12

Fig. 1. Blackjack game program.

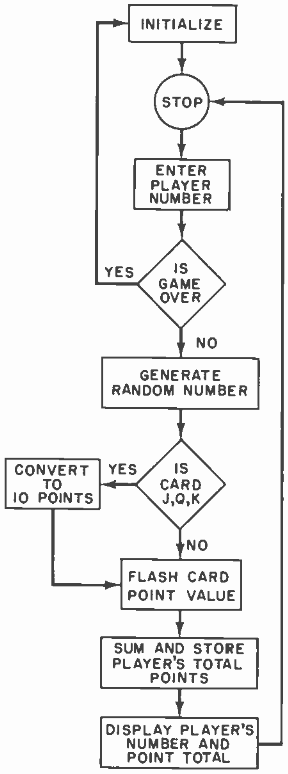


Fig. 2. Flow chart for the blackjack game.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEY ENTRY	OUTPUT DATA/UNITS
1	Key in program			
2	Initialize			
	Store U_0 ($0 \le U_0 \le 1$)	U_0	STO 3	
	Store constant	13	STO 4	
	Store constant	10	STO 6	
	Store constant	12	STO 7	
			f PRGM R/S	0.00
3	Key in player's #	1 or 2	R/S	Flashes card value. Displays player # and his total
4	Perform Step 3 until game is over			
5	To end the game	0	R/S	0.00
6	For new game, go to Step 3.			

Fig. 3. Instructions for running blackjack program.

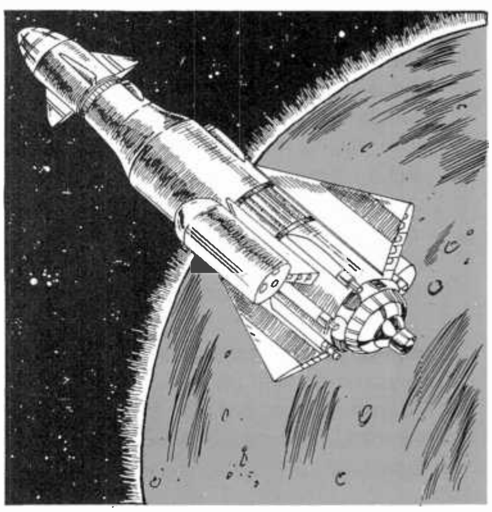
The winner of the game is the player who scores closest to, but does not exceed, 21 points. The game program and its flow chart are shown in Fig. 1 and Fig. 2, respectively.

The Program. To form an endless "deck" of 14 cards, a pseudorandom number generator is programmed from the equation U_i = fractional part of $(\pi + U_{i-1})^5$. The starting value, U_0, of the sequence is chosen such that $0 \leq U_0 \leq 1$. This forms a sequence of random numbers. When U_i is multiplied by 13, a card value from 0 through 12 is obtained. The point value of the card is the integer part of 13 multiplied by U_i. This random generator occupies steps 08 through 17 in Fig. 1.

Since no numbered card has a point value of 0, 1, or 12, the Jack, Queen, and King are assigned these numbers. The program uses conditional branching to test for their presence and converts them to a value of 10 points as needed. This is illustrated in program steps 19 and 23. If the answer to step 19 or step 23 is YES, execution continues downward and the program jumps to a subroutine at step 48. If the answer is NO, the program skips the following step and continues. The remainder of the 49-step program sets the display to flash the generated "card" and display the player's number and point total.

Instructions for running the program are given in Fig. 3. If an Ace is generated (11 points), the player can keep track of it mentally and elect to use it as 1 point by subtracting 0.1 from his score register. If at any time the player forgets his total score, he can find it in register R_1 or R_2. The last card can be found in register R_5.

—*Dale G. Platteter*



SPACE FLIGHT

● This program performs the calculations required to describe how an object (spacecraft) would move about in relation to two bodies (planets) of chosen sizes. No fancy display is needed; all you need are a programmable calculator, graph paper, and a pencil. The calculator tells you where the spacecraft is at any given time. You can "fly" the spacecraft yourself by inserting commands to accelerate or decelerate along the way. You can even land the spacecraft on one of the planets. And if you should crash it, the calculator tells you how hard you hit the planet.

Program Instructions. Choose a

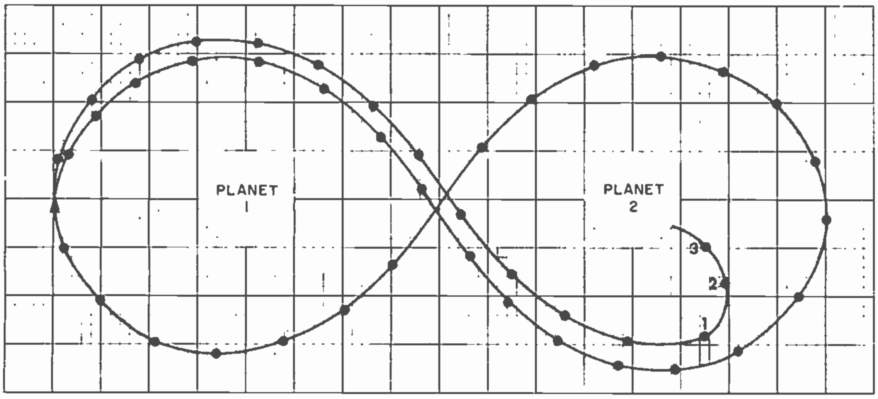


Fig. 1. Starting positions: x = − 2, STO 0; y = 0, STO 1. Starting velocities: x = 0, STO 2; y = .45, STO 3. Planet 1 radius .5, STO 4. Planet 2 radius .5, STO 5. Planet 2 = 4 divisions (step 24). Burns: 1 = − .3; 2 = −.3; 3 = − .4. Final velocity: .43 (ouch!).

starting point on the graph paper (see Fig. 1), which is the location of planet 1 and the point of origin of the horizontal (X) and vertical (Y) axes of the two-dimensional space in which you will be flying. When you move to the right, X increases in the positive direction and when you move upward, Y increases in the positive direction. For example, a point two divisions to the right and one division up would be labelled X2, Y1. When you move to the left or downward, the numbers do the same but are prefixed by minus signs.

Program the calculator as shown in Fig. 2. Key a 1 into step 12 and a 4 into step 24. Switch to the run mode, fix the display at two places, and return to address 00. The calculator is now ready to accept starting data.

We will use the data illustrated in Fig. 1 to demonstrate how a program works. Note that the two planets are of equal size. (Different-size planets can be used simply by specifying different radii for each.) Here, the radii are 0.5, which are keyed into registers 4 and 5. Planet 2 is located to the right of planet 1 by 4 divisions, although the two can be separated by any number between 1 and 9. It helps to draw appropriate-size circles on the graph paper at the selected planet locations. This helps you visualize how close you are getting to a landing.

Display Line	Key Entry	Comments
00		Set flag 0
01	0	Get distance to
02	RCL 1	body 1
03	RCL 0	
04	P→	Convert to radial
05	RCL 4	distance. Get
06	x ≥ y	body radius.
07	GTO 46	If distance < radius
08	x⇄y	show crash velocity.
09	x^2	
10	1/x	$G = 1/R^2$
11	X	$G = 1/R^2$ X Mass
12	(N)	
13	÷	Scale factor
14	R→	x,y format
15	STO − 2	Increment velocity
16	R↓	by acceleration
17	STO − 3	
18	R↓	Test flag, body
19	x ≠ 0	1 or 2?
20	GTO 29	Go to P + (V + A)
21	1	Set flag 1
22	RCL 1	Get distance to
23	RCL 0	body 2 by incre-
24	(N)	menting along x
25	−	axis by (N).
26	P→	Convert to radial
27	RCL 5	distance. Get
28	GTO 06	body 2 radius.
29	RCL 3	Return to V + A
30	STO + 1	
31	RCL 2	
32	STO + 0	P + (V + A)
33	P→	Get direction
34	x⇄y	of travel for use
35	STO 6	in input routine
36	RCL 1	Get Px, Py
37	RCL 0	
38	R/S	Display, take input
39	RCL 6	
40	x⇄y	
41	R→	Add input to
42	STO + 2	previous velocity.
43	x⇄y	
44	STO + 3	
45	GTO 01	Return to gravity
46	RCL 3	routine.
47	RCL 2	If crash, get
48	P→	last velocity,
49	FIX 9	display in 9 digit.

Registers

R_0 Position x	R_3 Velocity y
R_1 Position y	R_4 Radius Body 1
R_2 Velocity x	R_5 Radius Body 2
	R_6 Direction of travel (Ø)

Fig. 2. Space flight program.

Starting position and velocity of the spacecraft are inserted into registers 0 through 3. Placing an arrow to indicate the direction of travel at this point also helps in the visualization. These initial inputs simply start off the flight. Hereafter, there is a lot of moving about as time passes, owing to the gravities of the planets and the fact that you can command a change in speed at any time.

To start the flight, press R/S. What happens now is what would happen in space: Both planets attempt to attract the spacecraft, whose inertia tries to carry it forward, and the forces bring the craft to the position indicated when the program stops. The X coordinate is displayed first. To obtain the Y coordinate, press X↔Y. Make a dot at this point on the graph. Before starting again, press 0. This is necessary because the calculator is awaiting instructions from you on speed changes and will interpret the displayed number as such when it begins to step through the program again.

If everything goes okay, the spacecraft will fly a figure-8 around the planets forever. However, should you wish to land, insert a decelerating "burn" instead of 0 (−0.3 should do) and start again. The spacecraft will now begin to dip toward the nearest planet. If you are not careful, the craft will hit the surface hard. As you approach the surface of the planet, you must make your burns larger and larger. However, if you make them too large, you will begin to take off again, usually in an unexpected direction. Remember that the sign of the burn indicates an increase (+) or decrease (−) in speed along the direction of travel. So, if you observe that you have moved back from your last position and wish to keep receding from the planet's surface, you must key in + burns from then on. Lots of practice here helps.

If you should successfully touch down, the calculator indicates this by switching to a nine-digit display of the last velocity. Numbers greater than about 0.25 cannot really be called "touchdown."

To initiate a new flight, simply switch back to a two-digit display format, insert new position and velocity information, and press R/S. The planet positions and radii are not affected by running the program again. If you choose to use different-size planets or change the distance between the planets or both, you need only change step 24 and the contents of R4 and R5. Incidentally, flying with different-size planets is a real challenge, especially the landing phase.

—Paul Lutus

BIORHYTHM FORECAST

● Rhythmic changes in human behavior follow predictable cycles. A person's physical, emotional, and intellectual behavior is said to change with the cycles that have been determined to be 23, 28, and 33 days in length, respectively. Knowing this, a general statistical forecast of individual behavior can be made. This is what the calculator program described here does; it can tell you where you are in each of the three cycles for a chosen day.

As each of the cycles passes from one extreme to the other, you might experience days during which your abilities decline and be more likely to be involved in accidents. (Enough credibility is attached to this theory to make many companies forecast by computer biorhythms for their employees to warn them of their "critical days.")

The biorhythm cycles are said to begin at birth and, like built-in "clocks," follow us through life. The only information needed for running the Biorhythm Forecast program is your birthdate and the day to be forecast. The program first determines and displays the number of days between the two dates and then your position in each of the three cycles. The program itself is shown in Fig. 1. A circular graph, or Biorhythm Wheel (Fig. 2), can then be used to visualize the results and to spot upcoming critical days during which one or more of the cycles pass through the median line at the center. A day is said to be "super-critical" if two or three of the cycles rest in the median area at the same time.

Program Instructions. Load the program into your calculator as shown in Fig. 1. Then return the calculator to address 00. Insert the two constants used by the program by keying in 36525, STO, 5 and 30.55, STO, 6. Now, insert your birthdate in register 1 with the format month-month.day-day year-year. (For example, April 3, 1947 would be inserted as 4.0347, STO, 1.) Then insert the forecast date, using the same format, in register 2.

Be sure to return the calculator to address 00 and set the program to the run mode by operating the R/S key. When the program stops, the display will show the number of days between the two dates. Now key in 23 and operate the R/S key. The display will now have a number between 0 and 1 in it, which can be marked on the Biorhythm Wheel. (The use of the letters P, E, and I will help in marking the positions on the Wheel.)

For the emotional cycle, enter 28, R/S and for the intellectual cycle, 33, R/S. Mark these on the Wheel in the same manner.

When you are finished filling in your Biorhythm Wheel with the information generated by the calculator, numbers in the shaded area of the Wheel indicate a critical day. It is possible to foresee such days from a single forecast, such as a case where two cycles are in near-synchrony and moving toward the median (clockwise) in a group. You then key in two new dates, advancing the forecast a day, to clarify the situation.

When starting with new dates, always remember that the dates must be entered first, the program returned to address 00, and the R/S key operated. As written, the program works for dates in

Display Line	Key Entry
00	
01	0
02	STO 0
03	STO 3
04	3
05	RCL 1
06	x < y
07	GTO 11
08	2
09	STO - 3
10	R↓
11	INT
12	STO - 1
13	1
14	-
15	RCL 6
16	X
17	STO + 3
18	RCL 1
19	EEX
20	2
21	X
22	ENT↑
23	INT
24	STO + 3
25	-
26	RCL 5
27	X
28	STO + 3
29	RCL 0
30	x ≠ 0
31	GTO 39
32	RCL 3
33	STO 4
34	STO - 3
35	RCL 2
36	STO 1
37	STO 0
38	GTO 04
39	RCL 3
40	RCL 4
41	-
42	STO 0
43	R/S
44	RCL 0
45	x⇄y
46	÷
47	FRAC
48	GTO 43

Fig. 1. Biorhythm program.

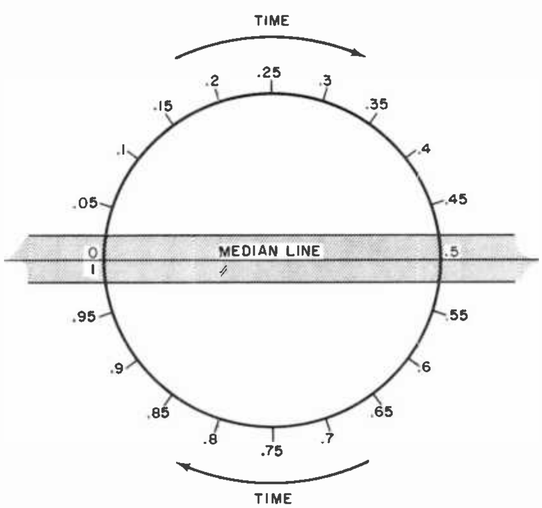
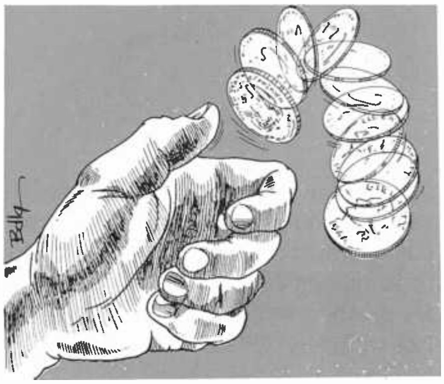


Fig. 2. Typical biorhythm wheel.

the 1900's. If you wish to use dates in a different century, the procedure to use is as follows. First, insert a new constant (3652500) in register 5. Now, the new date format is MM.DDYYYY (note the four digits required for the year). Hence, June 8, 1846 would be entered as 6.081846. This format makes it possible to look into the biorhythms of historical figures whose dates straddle turns-of-century. For example, who can resist the temptation to determine whether the Battle of Waterloo was fought on one of Napoleon's critical days?

—Paul Lutus



TEST YOUR ESP

● Have you ever had a strong hunch about something that later occurred exactly as you expected it to? Are you considered "lucky" by your friends? If so, maybe you have ESP (extrasensory perception). This program will help you to determine if you do.

The program electronically "flips a coin" and then compares your guesses with the results. It tells whether or not your guesses were correct and records the score for future use. After you have made a number of guesses and think you are doing pretty good, you can use the program to calculate the quality of your ESP.

Program Instructions. Key the program into your calculator according to the steps detailed in Fig. 1. Then clear all registers and insert a number between 0.1 and 10 into register 0. (This is the "seed" number that initiates the coin-toss routine.) Reset to address 00, fix a nine-digit display format, and key in your first guess, pressing either 0 or 1, and press R/S. The program will run and finally stop with either your guess filling the display or "Error" if you guessed wrong. You can go on guessing like this as many times as you wish; the calculator automatically keeps score. When you want to find out how well you are doing, you can recall registers 1 (how many tries) and 2 (how many correct guesses), and you can use the built-in probability calculator to evaluate your performance.

Display Line	Key Entry	Comments
00		
01	π	
02	RCL 0	
03	.	
04	5	
05	y^x	
06	FRAC	
07	STO 0	
08	1	
09	0	
10	X	Generate random number
11	INT	
12	2	
13	÷	
14	FRAC	
15	2	
16	X	
17	x = y	Compare with guess
18	GTO 25	
19	1	
20	STO + 1	
21	2	
22	$\cos^{-1}$	Wrong guess-"Error"
23	COS	
24	GTO 01	
25	1	
26	STO + 1	
27	STO + 2	
28	R↓	
29	.	
30	9	
31	÷	Right guess-display
32	GTO 00	
33	2	
34	RCL 2	
35	RCL 1	
36	2	
37	÷	
38	−	
39	$x < 0$	Calculate probability
40	GTO 43	
41	y^x	
42	GTO 00	
43	CHS	
44	y^x	
45	CHS	

Registers	
R_0	Seed N
R_1	Runs
R_2	Right guesses

Fig. 1. Program above and right.

Most of us would think a score of 75 out of a possible 100 is great performance, but a scientist would ask what the probability is that your score could have come about by chance. To find out the probability factor, key into register 1 the number 100, into register 2 75, GTO 33, R/S. The answer is 33,000,000, which means that the probability that the result came about by chance is 1 in 33,000,000!

At any time during a session, you can find the probability of your efforts in the same manner, simply by pressing GTO 33 and R/S. You can then resume testing, since the program always returns to the point at which a guess can be made without disturbing the collected score. If a minus sign appears in the display of the probability rating, you are getting more incorrect guesses than correct ones. This sometimes happens in ESP research. It is called "negative" ESP.

If you are serious about testing your ESP, sit down with the resolve to make a certain number of guesses. Many ESP research programs get into trouble because subjects turn in "good" runs and throw away "bad" ones. Over a period of time, this makes the ESP ability appear to be better than it really is. So, you should always make the same number of guesses without stopping short of or exceeding the planned number. If you think you have ESP ability, keep a record of your runs. You can then total all the figures, insert them in registers 1 and 2, and calculate an overall probability for the series.

Always use a different "seed" number in register 0, since a given number will always result in the same sequence of 1's and 0's, which might be memorized.

—Paul Lutus

PERFORMANCE CAPABILITIES OF 40-CHANNEL CB TRANSCEIVERS

R-f power output and modulation capabilities of expanded-band transceivers are examined.

BY BILL SCHERER*

RUMORS have been circulating to the effect that the new 40-channel CB transmitters are not as "powerful" as those in former 23-channel transceivers. Deficiencies such as lower r-f output, low modulation, etc., are principally cited. To set the record straight, these statements are unfounded. As a matter of fact, even the FCC has seen fit to put these rumors to rest by issuing Public Notice No. 77385 titled "CB 40 Channel Power Limits Unchanged."

To make sure of the situation for ourselves, we tested three typical 40-channel AM transceivers and compared our results to those obtained with older 23-channel rigs. Two of the transceivers were mobile types, while the third was a base station. All three were FCC type-accepted.

What the FCC Rules Say. The FCC's technical regulations still hold for *both* 40- and 23-channel CB transceivers. Specifically, the r-f carrier output must be limited to 4 watts on AM, with modulation held to within 100% on both the negative and the positive peaks. Single-sideband output must be held to 12 watts maximum peak-envelope-power (PEP), and a means must be provided for preventing the modulation from exceeding this or the rated power of the transmitter.

In the past, FCC type acceptance was often predicated on the manufacturer's say-so. The manufacturer simply presented his data to the FCC and received type acceptance as a matter of course. The eventual result was that many AM transceivers never really met the regulation-specified parameters, although they reached the market with FCC approval. While these transmitters usually were within the 4-watt output power limit, severe overmodulation, particularly on the negative peaks, was often possible, especially when using "power" microphones. This caused clipping carrier breakup, which, along with frequently used compression, produced a somewhat higher average modulating power. The foregoing was obtained at the price of high distortion and severe adjacent-channel splatter,

Strict adherence to the modulation capabilities is now being enforced with the new 40-channel transceivers. Now, transceivers must undergo type-acceptance tests at the FCC labs or the equivalent labs in Japan. Any adverse perfor-

*Bill Scherer has been writing technical communication articles for more than 30 years. For nine years, he was Technical Director for *CQ* magazine, where he was responsible for the technical reports on amateur equipment. Since 1970, Bill has been the reviewer for all the CB transceiver reports that have appeared in POPULAR ELECTRONICS.

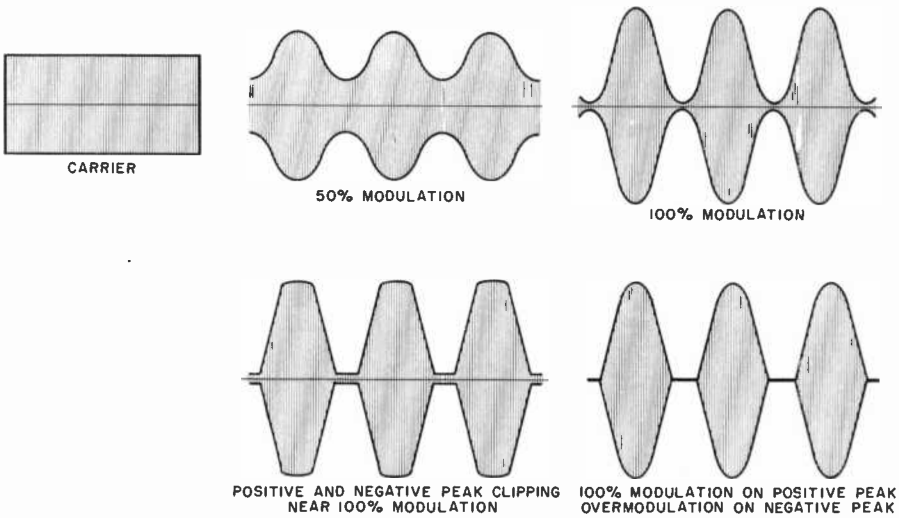


Fig. 1. AM r-f envelope displays on an oscilloscope with various degrees of modulation.

mance is no longer acceptable. This may have given rise to the false notion that the apparent average overmodulated power of older CB transceivers made them better than the new transceivers.

What We Observed. All three of the 40-channel AM transceivers we selected at random for our tests delivered 4 watts of r-f carrier output power. Transceiver A (mobile) employed a bootstrap automatic-modulation-control (amc) system at the microphone amplifier to hold the modulation on both peaks to just 100%. Even so, the excellent characteristics of the amc system allowed a very high *average* modulating power to be maintained within the required modulation limits, with very low distortion.

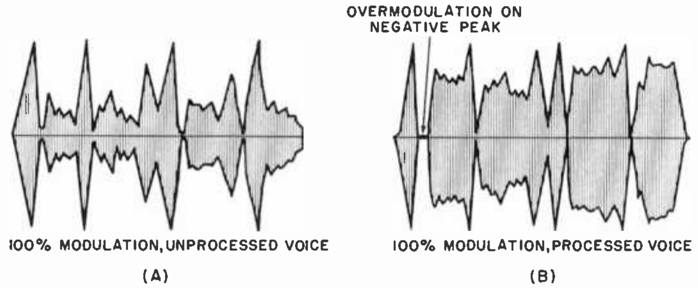


Fig. 2. R-f envelope display for complex wave (voice). Note higher average level for processed speech.

Transceiver B (base station) employed a low-level audio-frequency clipper and a low-pass filter (to minimize distortion products) that produced results similar to those obtained with Transceiver A, but with occasional peaks to 100%. Again, a high average modulating level was obtained.

Transceiver C (another mobile rig) employed still another type of amc system that also yielded high average modulation with an occasional insignificant degree of overmodulation on the negative peak.

All three of our test transceivers produced a high degree of clean, average modulated output power. The output in all three cases was as great as, if not greater than, that of most of the older 23-channel transceivers. Furthermore, no matter how loud we spoke into the microphone, we observed the same results, and the adjacent-channel splatter held to within 60 dB down (at greater than ±5000 Hz from the carrier frequency). Compare this figure with the 40-to-55-dB splatter figures obtained with many 23-channel transceivers of only last year and you will understand how much improved the new 40-channel tranceiver designs really are.

It should be noted that, for a given degree of relative average modulation, the aural difference between a 90% and a

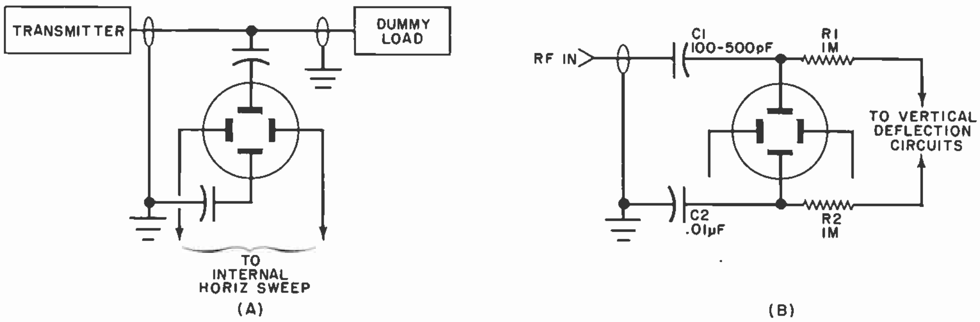


Fig. 3. Scope connections with r-f input connected directly to vertical plates (A) and temporary modification to scope not equipped for r-f inputs (B).

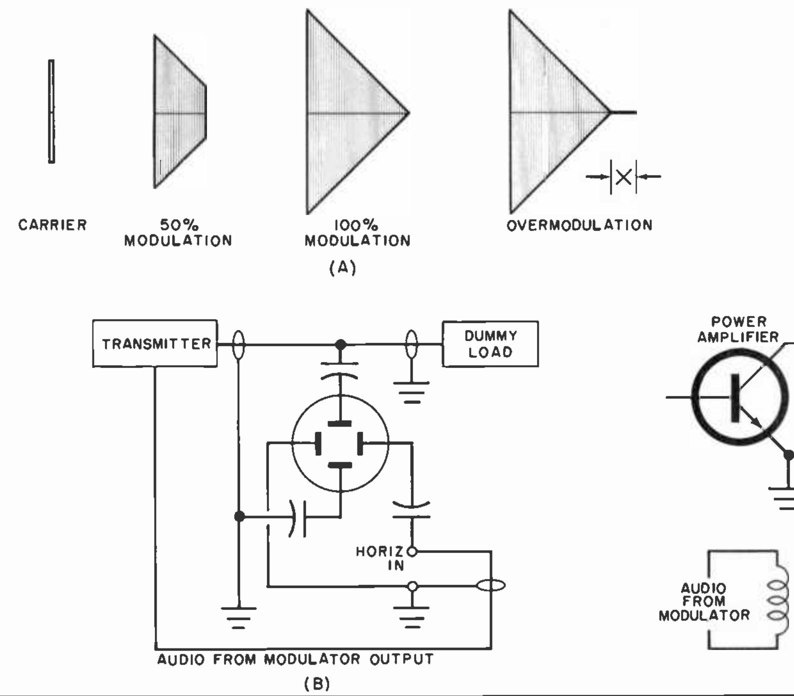


Fig. 4. Trapezoid displays (A) are obtained by feeding r-f to vertical plates and a sample of modulator's output to horizontal input (B). Hookups to transceiver are at (C). This is a more accurate method of indicating overmodulation, though r-f envelope displays are better for noting high average modulation.

100% modulated signal is minimal and insignificant. It amounts to less than 0.5 dB. Therefore, if your transceiver does not always quite reach a 100% modulation level, there is no need to be particularly concerned.

If you want more power (and range), you can always communicate via SSB, which is a considerably more efficient medium than AM. For a given expended power, SSB gives an effective signal-level increase of up to 9 dB over AM. This translates into an eight-fold relative power improvement, which is equivalent to raising the 4-watt output power of an AM transmitter to 32 watts. Additionally, by engaging the USB or LSB mode, a 40-channel transceiver yields up to 80 possible SSB communication channels, thereby saving spectrum space and thus alleviating user crowding.

Viewing Modulation Waveforms. Now let us see how various modulating conditions are displayed on the CRT of an oscilloscope. Typical r-f envelope patterns for a carrier modulated with a steady-amplitude, single-frequency test tone are shown in Fig. 1. The waveforms in Fig. 2 illustrate the display for a voice-modulated carrier without (A) and with (B) speech processing. These waveforms can be displayed by feeding the transmitter's output (using a dummy load in place of the antenna) directly to the vertical deflection plates of an oscilloscope (see Fig. 3A).

If your oscilloscope does not have provisions for direct r-f input, you can make the appropriate connections temporarily with isolating resistors (to prevent r-f energy from backing up into the other circuits in your scope) as shown in Fig. 3B.

The waveforms shown in Fig. 4A illustrate a trapezoid display that is obtained by feeding the r-f directly to the scope's vertical-deflection plates and applying a sample of the modulator's output signal to the scope's ac-coupled horizontal input. (See Fig. 4B for details.) The hookups to the transceiver are illustrated in Fig. 4C. Note that the modulator signal is picked off the test point on the +12-volt power bus side of the choke (rfc) in the power amplifier's collector circuit. (If the power-amplifier stage is emitter modulated, a similar test point in the emitter circuit is used for the modulator signal pickoff.) A test point is usually provided at the appropriate locations in the circuit.

The waveforms shown in Fig. 5 illustrate the r-f envelope displays of an SSB signal obtained with the scope setup shown in Fig. 3A. Two nonharmonically related test tones (such as 800 and 1800 Hz) are applied to the microphone input. Their levels are equalized to bring the displayed "valleys" together at the horizontal axis for this test.

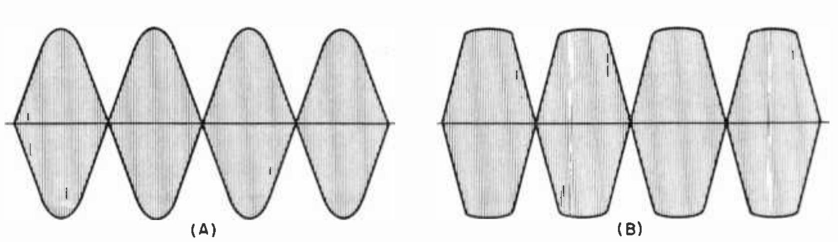
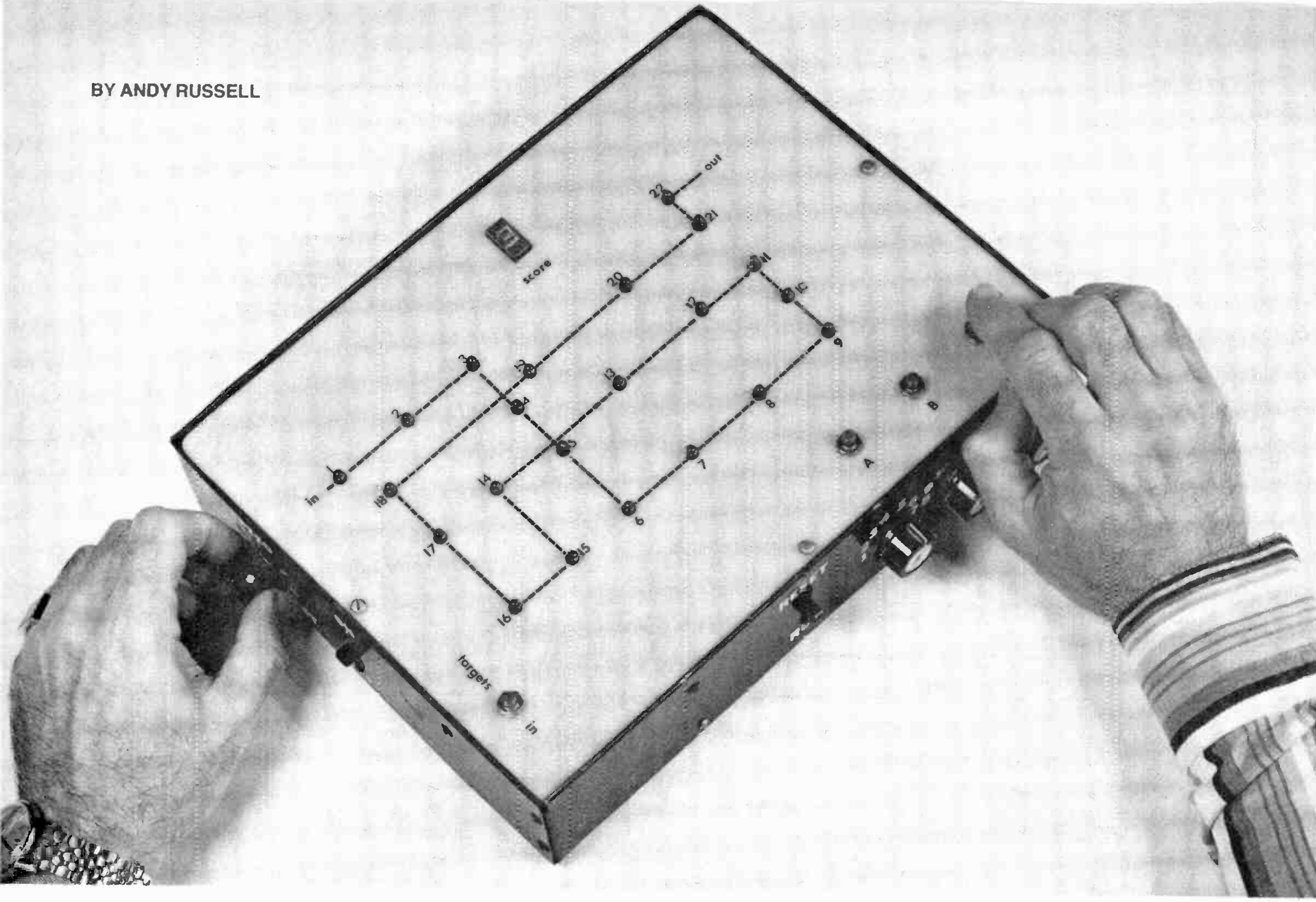


Fig. 5. R-f envelope displays of SSB signal: (A) shows good linearity and low distortion; (B) shows effects of excessive drive or overmodulation.

In Conclusion. As you can see from the tests of three randomly selected new 40-channel AM CB transceivers (from different manufacturers), there are no real grounds for the rumors pertaining to inferior performance. This does not mean that every 40-channel CB transceiver exhibits top performance. There were, in truth, some models that performed poorly in the early FCC test program due to the zeal of some manufacturers to obtain quick FCC type acceptance. These models were generally warmed-over 23-channel designs which, in order to meet new FCC radiation and spurious response requirements, were less powerful than they should have been. (Lower than maximum power or modulation capabilities are not FCC test criteria.) But, by and large, the new transceivers are capable of superior performance when compared with the older 23-channel transceivers we have been using. ◇

BY ANDY RUSSELL



BUILD THE LED TARGET GAME

Test your "eye" and reaction time by trying to shoot a moving target.

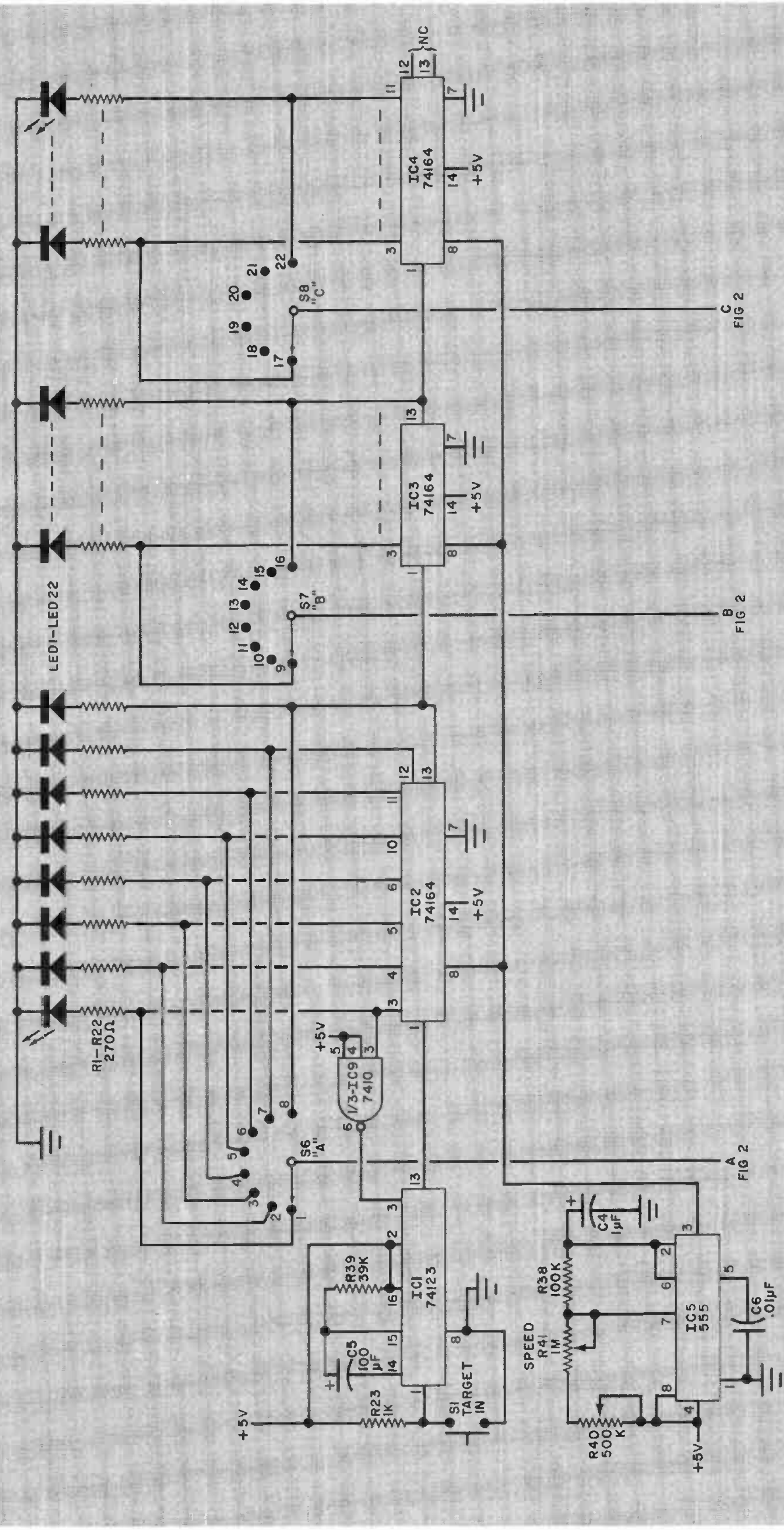
THE LED Target Game consists of 22 LED's numbered sequentially along a random track with a circuit to control them so that one LED at a time turns on in sequence to give the appearance of a single glowing LED moving along the track. The person who is the first player can select the speed at which the glowing LED moves. He can also initiate the trip and cause more than one glowing LED to appear on the track to complicate the game. These moving, glowing LED's become targets.

The person who is the second player can select three positions (via three rotary switches) at which he will attempt to hit the targets. Thus, when the LED at a selected position glows, he operates a pushbutton associated with that position and, hopefully, "shoots" the LED. As each coincidence is made, a conventional decade counter using a 7-segment readout accumulates the hit score. Several rules for playing the game are suggested in this article, but they can be modified as wished by the players.

How It Works. Timer *IC5* (Fig.1), is a variable-rate clock generator whose frequency can be set between 0.8 and 6 Hz via front-panel potentiometer *R41*. The timer pulses are applied to the clock inputs of three serial-in, parallel-out 8-bit shift registers *IC2, IC3, and IC4.*

The three shift registers are connected in series so that when a "1" is inserted into the serial input of *IC2*, it will be propagated down the three shift registers at the clock frequency. The "1" is inserted into *IC2* by operation of one-shot *IC1* by *S1*, the TARGET IN switch.

As each output of each shift register goes high, it applies current to an associated LED via a current-limiting resistor. Thus, as the "1" propagates down the line, each of the 22 LED's will be illuminated in turn, at a rate determined by the selected clock speed.



PARTS LIST

C1, C2, C3—10-µF electrolytic capacitor
C4—1-µF tantalum capacitor
C5—100-µF electrolytic capacitor
C6—0.01-µF capacitor
DIS1—Common-anode 7-segment display
IC1—74123 dual one-shot
IC2, IC3, IC4—74164 serial-in parallel-out 8-bit shift register
IC5—555 timer
IC6, IC7, IC8—74121 one shot
IC9—7410 triple 3-input NAND gate
IC10—7400 quad 2-input NAND gate
IC11—7490 decade counter
IC12—7446 BCD-to-7-segment decoder driver
LED1 through LED22—Conventional red LED
R1 through R22—270-ohm, ¼-W, 5% resistor
R23 through R27—1000-ohm, ¼-W, 5% resistor
R28 through R34—220-ohm, ¼-W, 5% resistor
R35, R36, R37, R39—39,000-ohm, ¼-W, 5% resistor
R38—100,000-ohm, ¼-W, 5% resistor
R40—500,000-ohm trimmer potentiometer
R41—1-megohm potentiometer
S1 through S4—Normally open pushbutton switch
S5—Spst switch (or half of a dpst switch)
S6, S7, S8—Single-pole 8-position rotary switch
Misc.—Suitable cabinet and plastic top (approximately 12" by 9"), knobs (4), battery holder (4 D cells), hookup wire, dry-transfer lettering, etc.

Fig. 1. Timer IC5 clocks a "1" generated by IC1 down the three series-connected shift registers, whose outputs drive LED's. Three switches allow selection of any LED in either shift register.

One of the eight outputs of *IC2* can be selected by rotary switch *S6*, one of the eight outputs of *IC3* can be selected by *S7*, and one of the six outputs from *IC4* can be selected by *S8*.

As shown in Fig. 2, each of these switch outputs is passed to a two-input NAND gate with the other gate input coming from an associated one-shot. Since each NAND gate will have a zero output when both inputs are high at the same time, it takes a coincidence between the switch-selected input and the associate one-shot firing when it's push-button switch is operated.

The three coincidence NAND gate outputs are fed to a single 3-input NAND *(IC9)* whose output is used to drive dec-

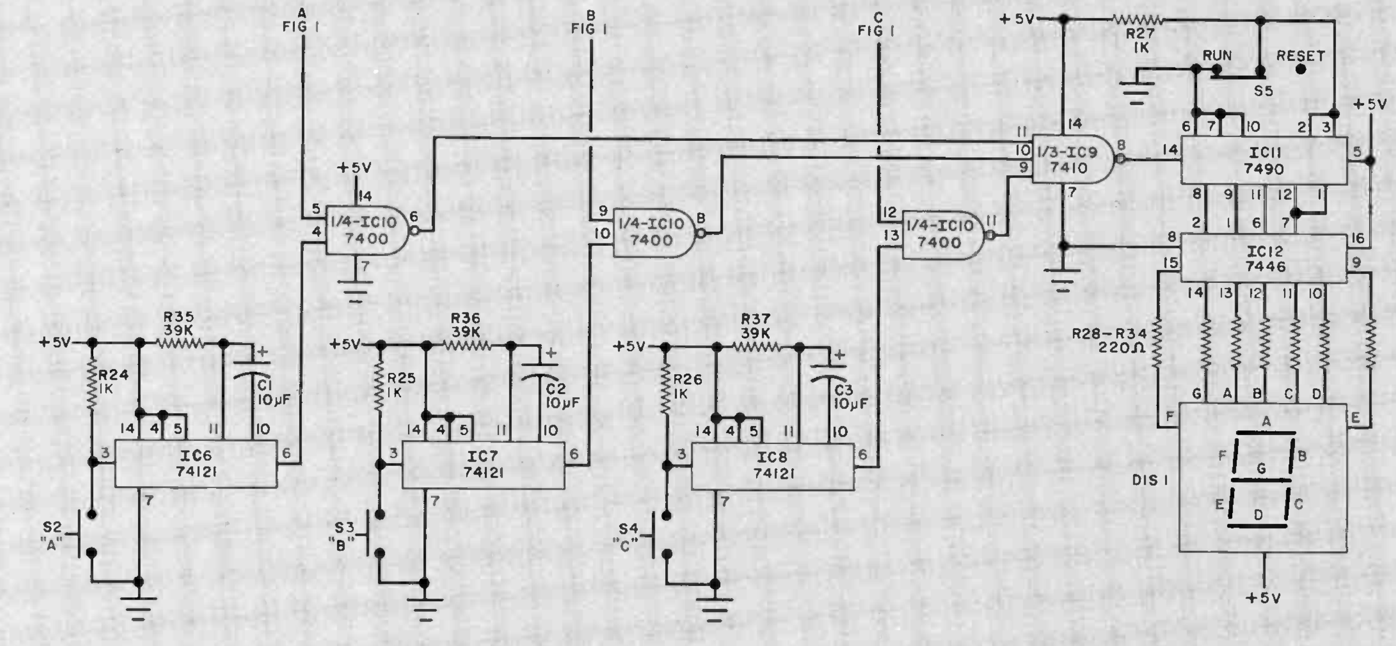


Fig. 2. Each selected LED line is coincidentally NAND gated, with each coincidence added on a decade counter, seven-segment LED readout.

ade counter *IC11*. This counter is connected to a conventional BCD-to-7-segment decoder *IC12* that in turn drives a 7-segment common-anode LED display *(DIS1)*.

When playing the game, each switch *(S6, S7,* and *S8)* is set to a particular LED output line before the TARGET IN switch *(S1)* is operated. When the LED's start their sequential action, switches *S2, S3* and *S4* must be depressed just when the selected LED comes on. If a coincidence is made, then a count will be entered in the decade counter and displayed on the readout. Holding *S2* through *S4* down constantly will not work since their associated one-shots will work only once for each switch depression.

Construction. The electronic circuit, other than the various switches, LED's, and *DIS1*, can be assembled on a piece of perforated board using sockets for all IC's. Make suitable connector pins so that the LED's and *DIS1* can be connected to their respective current-limiting resistors.

In the prototype, the main "playing field" was made from a 12" by 9" piece of plastic, that was fitted into some form of supporting framework. The top of the playing field was marked with a random track (see photo) with each of the 22 LED's mounted within tight-fitting holes placed along the random track. *LED1* should be at the beginning of the track, and *LED22* at the end. Using press-on type, mark the track with dotted (or dashed) lines and clearly identify each LED from 1 to 22 in the sequence.

The 7-segment display should also be mounted on the upper surface of the plastic top, along with TARGET IN *(S1)*, and pushbutton switches "A" *(S2)*, "B" *(S3)*, and "C" *(S4)*. The three rotary switches *(S6, S7* and *S8)* should be mounted on the side wall of the support structure with each directly under its associated pushbutton switch. Speed control *R41*, and the power on-off switch are mounted on the side closest to the TARGET IN switch.

The power supply can be a simple 5-volt regulated system using a 6.3-volt transformer, diode rectifier and filter driving any 5-volt regulator IC. If desired, the system can be powered by four D-cells mounted in a plastic holder, using a 0.47-ohm series resistor to drop the voltage to 5 volts.

Testing the Game. Turn on the power and note that some of the LED's may be lit, with the lit sequence travelling along the 22-LED chain until it reaches *LED22*. Place RUN/RESET SWITCH *(S5) to the* RESET position and note that *DIS1* indicates a zero. Set *S5* to RUN. Position the three rotary switches (*S6* through *S8)* to some selection of LED'S. Switch *S6* selects from LED positions 1 through 8, *S7* from 9 through 16, and *S8* from 17 through 22.

With SPEED control *R41* set for a slow speed (maximum resistance), operate the TARGET IN pushbutton. Starting with *LED1*, each LED will illuminate in turn down the series. When the LED at the switch selected position glows, operate the associated pushbutton switch. If a coincidence is made, the readout will indicate a hit. Speed control *R41* can be set from fast to slow, and can be trimmed as desired by *R40*.

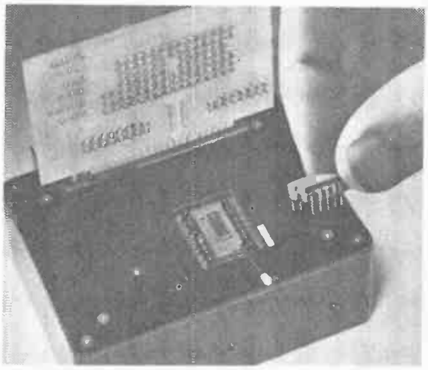
Playing the Game. Two players are suggested, one to set the speed and initiate the LED travel, and the other to set the rotary switches and operate the three pushbuttons.

Once the first player initiates the LED travel, it is up to the other player to set his switches and hit his pushbuttons to cause a coincidence. Of course, the first player can initiate more than one LED at a time, but in the interests of sanity, he should not have more than three LED's going at one time. They should be spaced some selected numbers apart. The first player can also set the travel speed, or vary it while the game is in progress.

The second player pre-selects his numbers before any targets are sent through, and the first player should not see which positions have been selected.

The game is played in four quarters of 10 targets each with each "hit" called out on the readout. At the end of each quarter, the two players change places and play again. The winner is the player that has the highest cumulative score out of 40 targets. ◇

- **BUILD A DIGITAL IC TESTER**
- **GUIDE TO OSCILLOSCOPES**
- **A 40-MHZ FREQUENCY COUNTER PROJECT**
- **ACCURATE MILLIAMMETERS ON A BUDGET**



BUILD A DIGITAL IC TESTER

Inexpensive project tests DTL and TTL IC's.

BY R. M. STITT

TESTING digital integrated circuits has posed a problem to experimenters ever since the devices were made available at the hobbyist level. After all, many hobbyists were not about to spend thousands of dollars for a commercial, general-purpose digital IC instrument. The tester presented here, however, can be constructed for just a few dollars and provide quick and accurate checks of 14- and 16-pin DTL and TTL IC's.

The operating principle is simple. Logic states of the questionable IC are compared to one of the same type that's known to be good. A testing program is set up via patch cords and the IC's are plugged into their respective sockets, at which time the unit automatically runs through the program. Even the most complicated test program will be performed about 40 times per second.

A good/bad LED indicates the overall status of the device. Furthermore, 16 LED's (one for each pin) isolate faults to specific pins so that bad sections or functions can be detected. These fault LED's are also useful for debugging test programs.

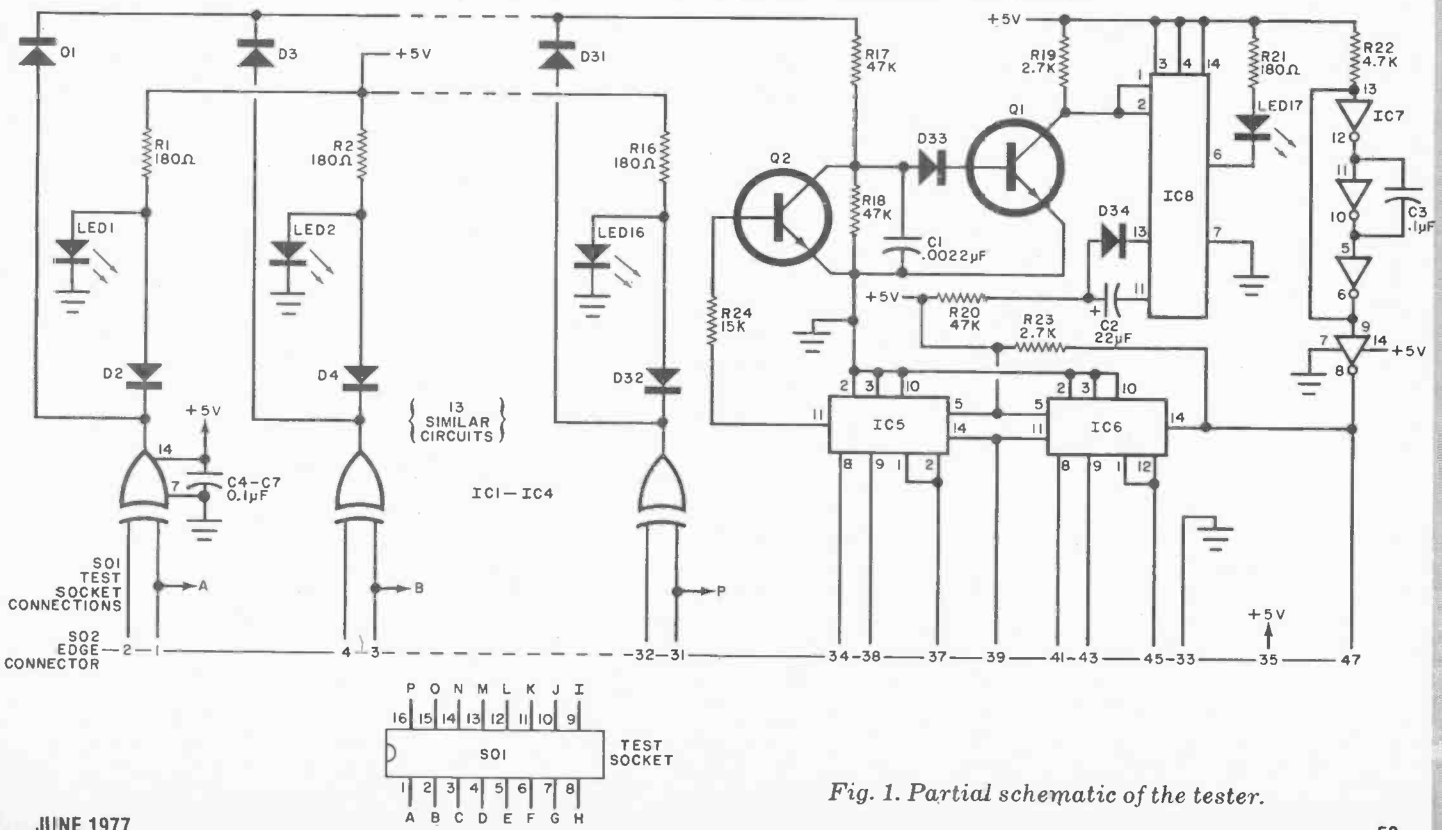


Fig. 1. Partial schematic of the tester.

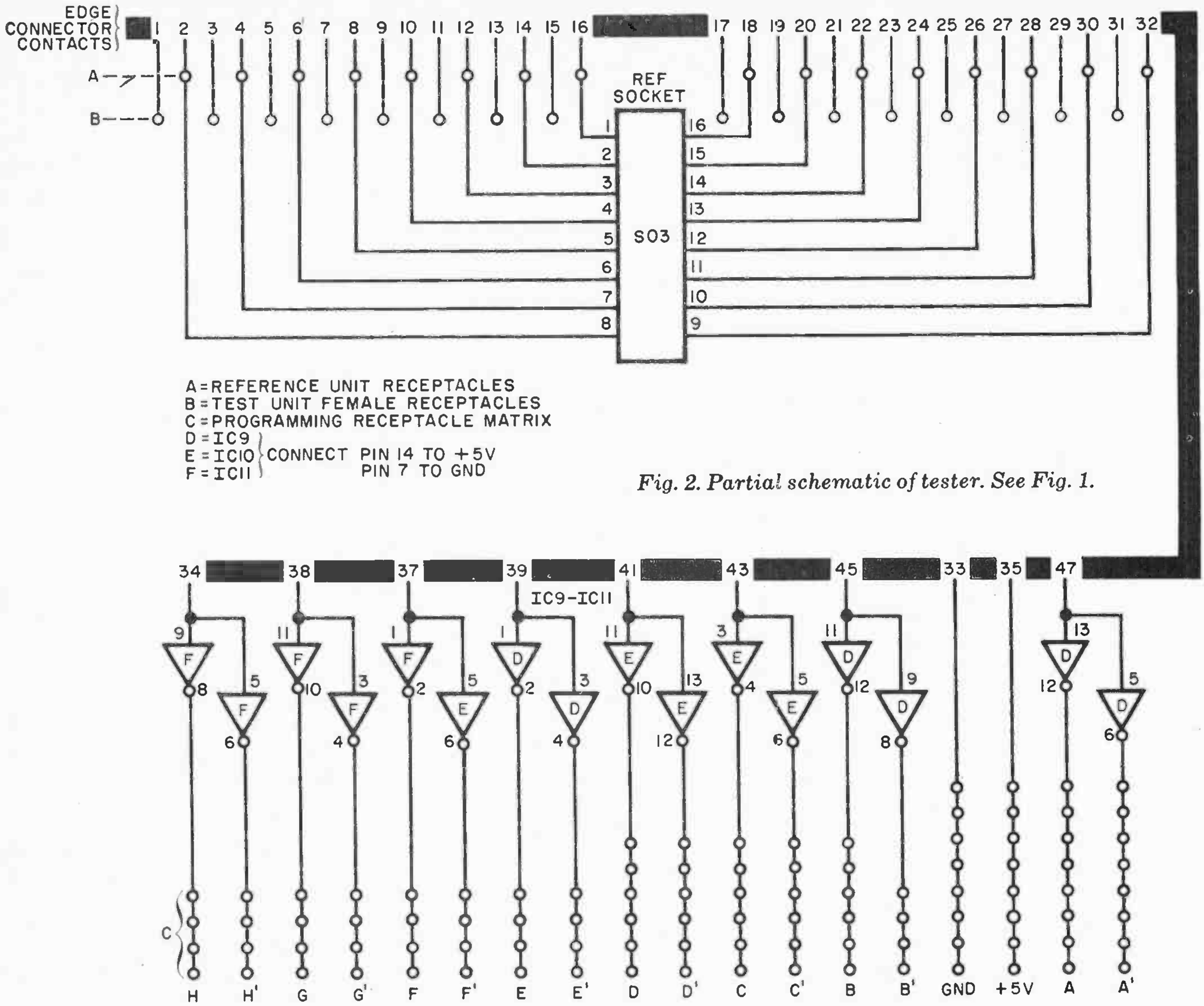


Fig. 2. Partial schematic of tester. See Fig. 1.

About the Circuit. The tester puts both IC's through their paces in parallel, covering all possible input combinations. The logic state at each input and output pin is continuously monitored and compared to the reference IC. If there is a discrepancy with any input combination, the IC under test is defective and a fault will be indicated by the IC tester.

The schematic diagram of the IC tester is shown in Figs. 1 and 2. The basic element for the electronic comparison is the exclusive-OR gate. Four two-input, exclusive-OR gates are contained in each SN7486 package (*IC1* through *IC4*), for a total of 16 gates. One input of each gate is hardwired to the test IC socket (*SO1*) for individual pin monitoring. The other gate input is hardwired through programming-board edge connector *SO2* to the corresponding pin on the programming board's reference IC

PARTS LIST

- C1—0.0022-µF disc ceramic capacitor
- C2—22-µF, 10-V tantalum capacitor
- C3 through C7—0.1-µF disc ceramic capacitor
- C8—3000-µF, 25-V electrolytic capacitor
- C9—10-µF, 10-V tantalum capacitor
- D1 through D34—1N914 switching diode
- D35, D36—1N4001 rectifier diode
- IC1 through IC4—SN7486 quad 2-input exclusive-OR gate
- IC5, IC6—SN7493 4-bit binary counter
- IC7—SN7405 open collector hex inverter (do not substitute)
- IC8—SN74122 retriggerable monostable multivibrator
- IC9 through IC11—SN7404 hex inverter
- IC12—LM309K 5-volt regulator
- LED1 through LED 17—Light emitting diode (TIL-32 or similar)
- Q1, Q2—2N3904 npn silicon transistor

The following are 5% tolerance, ¼-watt carbon composition resistors:

- R1 through R16, R21—180 ohms
- R17, R18, R20—47,000 ohms
- R19, R23—2700 ohms
- R22—4700 ohms
- R24—15,000 ohms
- SO1—Zero-insertion-force 16-pin DIP IC socket (Textool No. 216-330M or equivalent)
- SO2—48-pin edge connector (Amphenol No. 2-583660-3 or equivalent)
- SO3—16-pin DIP IC socket
- T1—20-volt center-tapped, 1-ampere transformer (Burstein-Applebee No. 18A 1626-1 or equivalent)
- Misc.—Suitable enclosure (Harry Davies No. 260K with No. 261 cover, or equivalent), printed circuit boards, No. 4 × ¼" standoffs, suitable programming receptacles and patch cords, heat sink, thermal silicone compound, machine hardware, hook-up wire, solder, etc.

Note: See Fig. 4 for information on ordering pc boards.

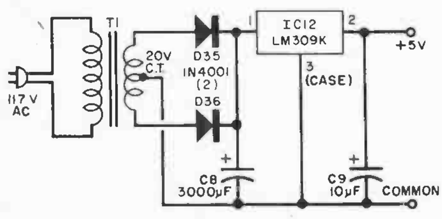
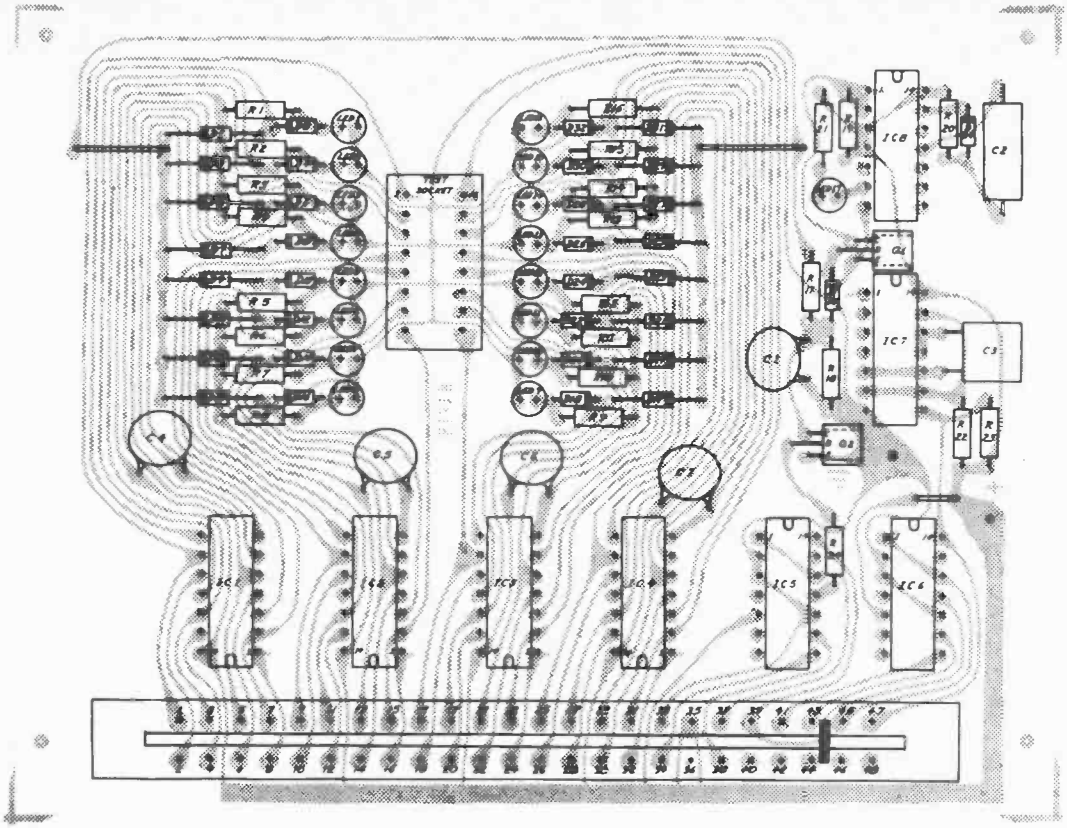


Fig. 3. Schematic for a suitable power supply.



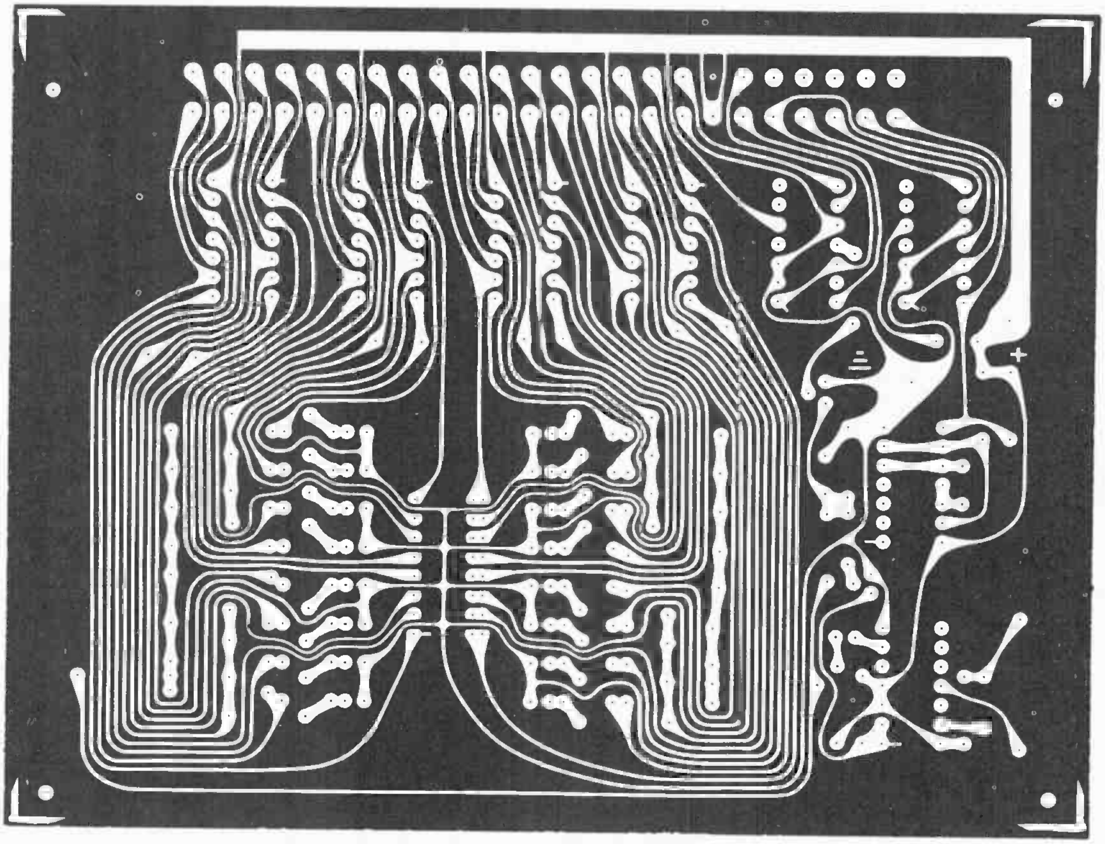
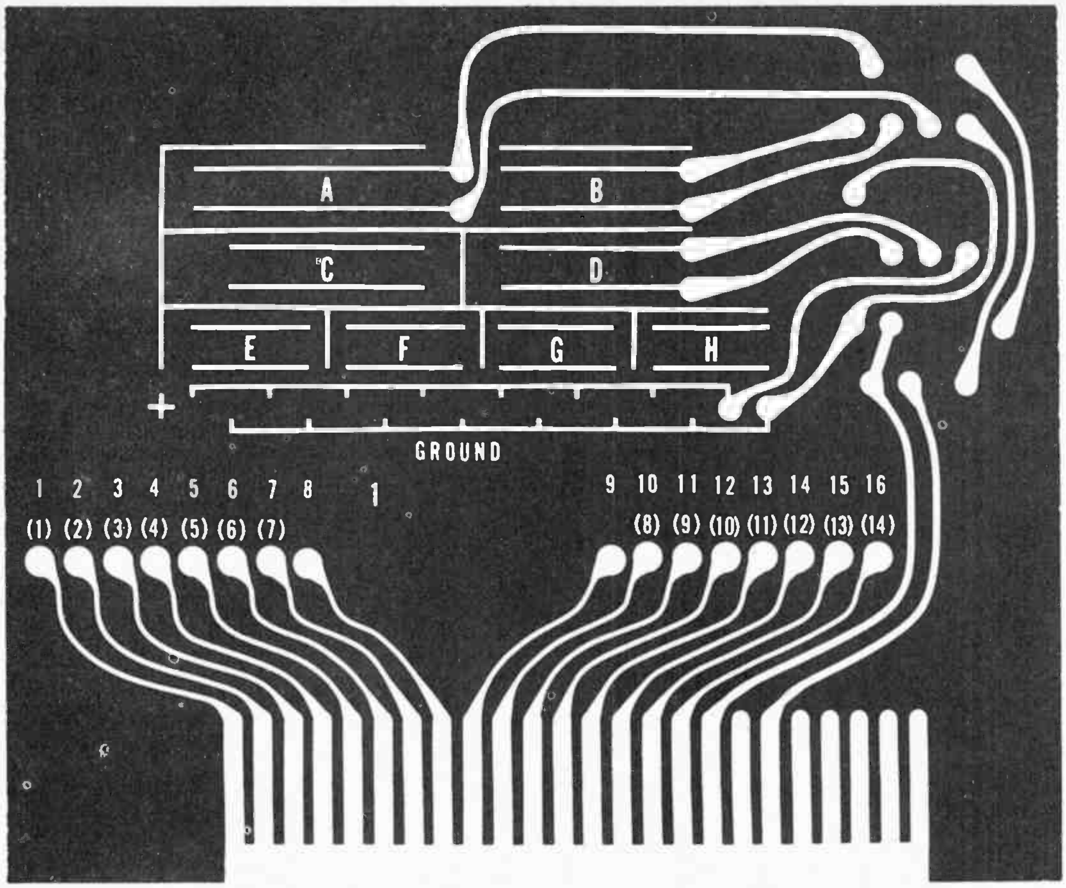


Fig. 4. Etching and drilling guide (right) and component layout (above) for main pc board. Note: etched and drilled pc boards for this and Fig. 5 are available from Select Circuits, 1411 Lonsdale Rd, Columbus, OH 43227 for $18.95 a pair.

socket (*SO3*). Each exclusive-OR gate thus yields a logic-one output signal whenever its two input signals have different logic states. In other words, a logic one appears at the output of each gate when a discrepancy of performance between the test and reference IC's is detected.

Two fault indicator circuits are employed. A LED (*LED1* through *LED16*) at the output of each exclusive-OR gate glows when an error at the corresponding test IC pin is detected. Additionally, a master fault indicator (*LED17*) glows when one or more exclusive-OR gate output is high. Diodes *D1, D3, D5*. . . *D31* are connected to *R17* and to the exclusive-OR outputs to form one large OR gate. A pulse stretcher is included in the master fault indicator circuit to insure that *LED17* will glow at full brilliance no matter what the duty cycle of the fault signal is. This is very important because it's possible for a fault signal to have a



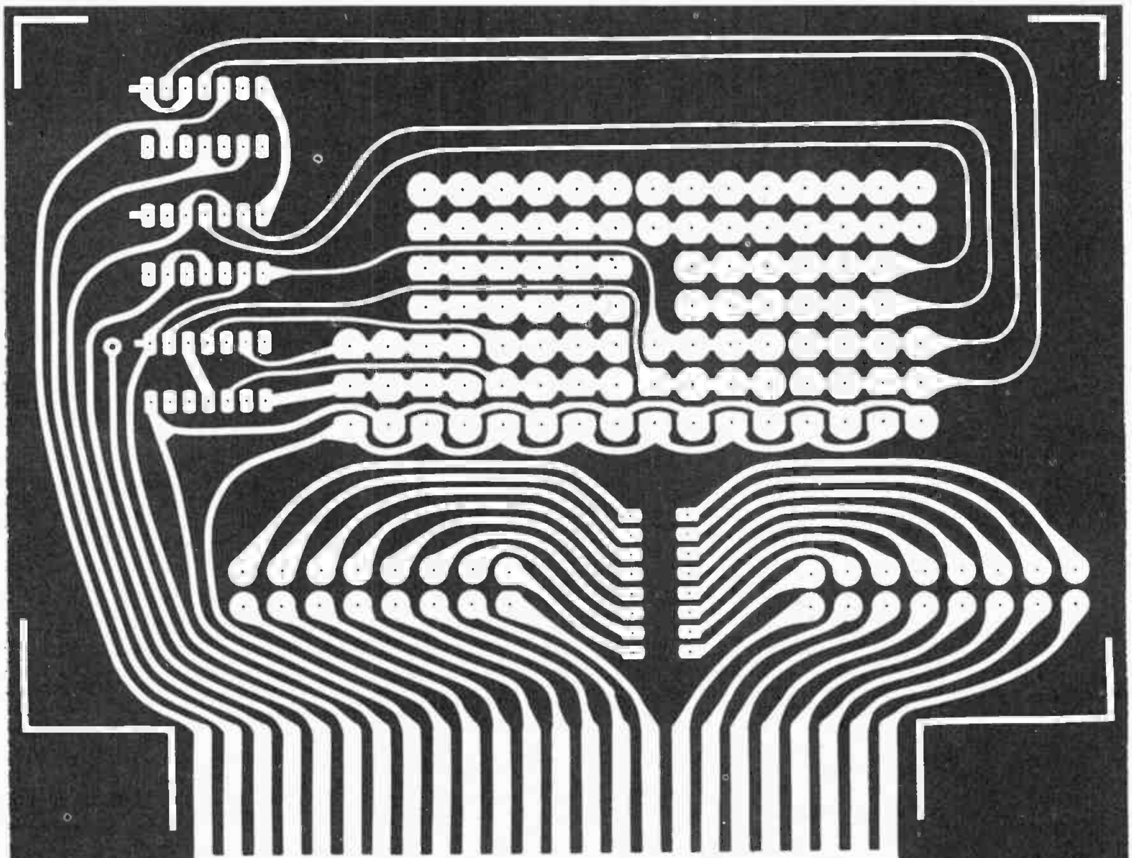


Fig. 5. Etching and drilling guides for both sides of the programming pc board. See Fig. 4 for ordering information.

duty cycle as low as 0.4%. It would be difficult, if it were even possible, to detect light output from a LED driven by such a signal. The circuit also includes a low-pass filter (*R17, R18* and *C1*) at the master fault input to reject noise spikes which might otherwise generate a deceptive fault indication.

The diode OR gate drives pulse stretcher *IC8* (an SN74122 monostable multivibrator) and its associated components (*C2, D34,* and *R20*) through input conditioners *D33* and *Q1*. Because a continuous fault indication at the pulse stretcher input would trigger the one

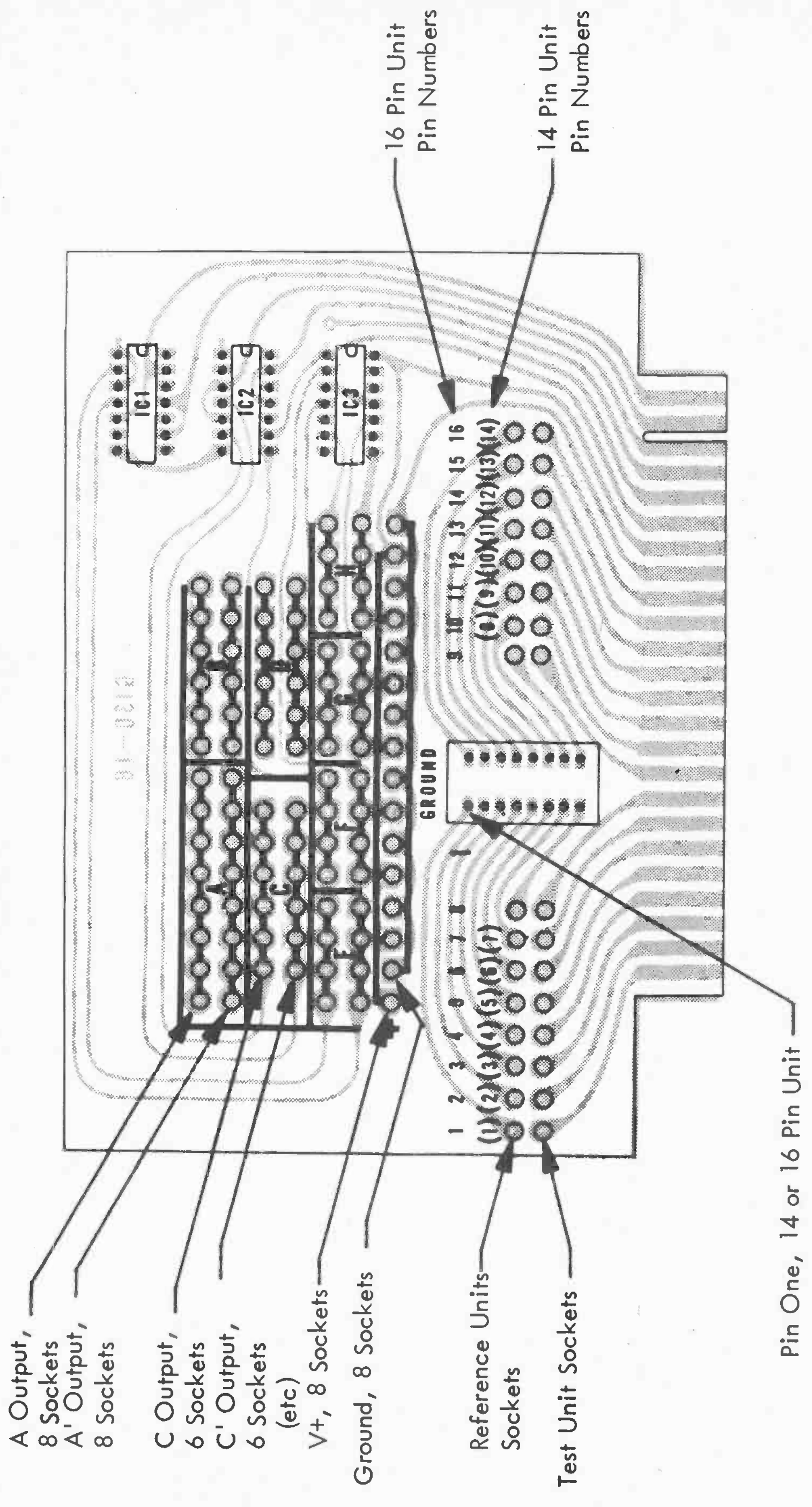


Fig. 6. Component placement guide for programming pc board.

shot for but one test cycle, the input must be periodically reset. This is accomplished by transistor *Q2*, which is driven by the last stage of a binary code generator.

To provide all possible test input combinations, an eight-stage binary code generator (*IC5* and *IC6*, SN7493 4-bit counters) is incorporated. It is driven by a free-running square-wave generator consisting of *C3*, *R22*, and *IC7*, an SN7405 hex inverter. The square-wave generator provides a clock signal at about 5000 Hz. The clock output and the outputs from the first seven stages of the binary code generator are available at edge connector *SO2*. Thus there are eight independent test input signals present on the programming board. The eighth stage of the binary code generator is used to reset the master fault indicator, as mentioned earlier.

The programming board interfaces with the main tester board via 48-pin edge connector *SO2*. This allows prewired program cards to be kept on hand and simply plugged into the tester for quick checks of common IC's. Each bit of the binary code is independently buffered by sections of *IC9* through *IC11* (SN7404 hex inverters) to drive both the reference and test IC inputs. Separate buffering for all inputs of each IC ensures that such logic-overriding faults as input short circuits will be detectable.

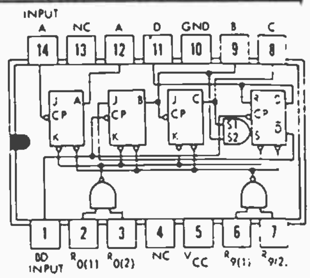
The tester is powered by a simple 5-volt, 1-ampere regulated supply (Fig. 3). Ac from *T1* is converted to pulsating dc by a full-wave rectifier (*D35* and *D36*) and filtered by *C8*. Unregulated dc is then applied to *IC12*, an LM309K 5-volt regulator, which is essentially blow-out proof. Current limiting is built in to the IC, as is thermal shutdown. Output bypass capacitor *C9* provides increased stability and improved transient response.

However, other power supply configurations can be used. For example, *T1* could be a 12.6-volt, 2-ampere transformer driving a bridge rectifier. The output of the bridge would then be filtered and regulated as in Fig. 3.

Construction. Assembly of the tester is not critical. However, the use of pc boards will simplify the task. Etching and drilling guides for the main and programming boards are shown in Figs. 4, 5, and 6. The main pc board contains most tester components mounted in a conventional manner. It in turn is mounted on four ¼-inch (6.4-mm) No. 4 standoffs behind the front panel of a molded plastic box. Holes are cut in the front panel for the test socket, the sixteen indicator

Reference Unit Connection	A'	NC	NC	NC	COM	NC	NC	X
Test Unit Connection	A	NC	NC	NC	COM	NC	NC	X
Pin Number	(14) 16	(13) 15	(12) 14	(11) 13	(10) 12	(9) 11	(8) 10	X

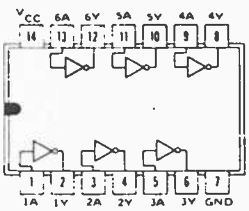
DEVICE TYPE: **CIRCUIT TYPES SN5490, SN7490 DECADE COUNTERS**



Pin Number	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	X
Test Unit Connection	B	C	D	NC	V+	E	F	X
Reference Unit Connection	B'	C'	D'	NC	V+	E'	F'	X

Reference Unit Connection	V+	B'	NC	B'	NC	B'	NC	X
Test Unit Connection	V+	B	NC	B	NC	B	NC	X
Pin Number	(14) 16	(13) 15	(12) 14	(11) 13	(10) 12	(9) 11	(8) 10	X

DEVICE TYPE: **CIRCUIT TYPES SN5404, SN7404 HEX INVERTERS**



Pin Number	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	X
Test Unit Connection	A	NC	A	NC	A	NC	COM	X
Reference Unit Connection	A'	NC	A'	NC	A'	NC	COM	X

NOTES: All inputs could have been tied in parallel to A & A' for example, but it is not necessary to do so.

Fig. 7. Sample programming sheets for testing decade counters (above) and hex inverters (below).

LED's, the master fault indicator and the edge connector.

Before mounting any components on the main board, use it as a template to locate holes and cutouts on the front panel. It can be clamped to the front panel and used as a drilling guide for the four standoff mounting holes. The locations of the master fault indicator, the test socket, and edge connector can be specified by marking the corners of each cutout. Components which do not protrude through the front panel must be mounted flush to the main pc board so that they will not interfere with the fit of the board to the front panel. If LED's with base diameters larger than 0.200" (5.08 mm) are used for the sixteen fault indicators, their bases must be filed so that a proper fit is obtained. The author recommends the use of a 16-pin zero-insertion-force (Textool No. 216-330M or equivalent) IC socket for the test IC location. A conventional DIP socket can be substituted, of course, but is much less convenient to use for many IC's.

The programming board is double-sided. Because most builders will not be able to produce plated-through holes, IC and socket pins, as well as programming receptacles must be soldered (where applicable) to both sides of the board. The programming receptacles and jumpers (patch cords) are a matter of preference. The solder pads on the pc board are large enough to accept eyelet sockets for the 0.040" (0.916-mm) pin terminated type of patch cords. The most economical programming patch cord is simply a length of No. 22 or 24 solid insulated hookup wire. The wire should be cut to the desired length and about ½" (1.27 cm) of insulation stripped from each end. If diagonal cutters are used to trim wire length, position the cutters so that their hollow side faces the body of the jumper when the wire is clipped. Then a point will be formed on the wire, making it easier to insert the jumper into a programming receptacle.

A solid wire jumper is best accommodated by a 0.020" (0.458-mm) receptacle. No. 24 wire is approximately 0.020" (0.458 mm) in diameter and fits such a receptacle exactly. No. 22 wire is about 0.005" (0.127 mm) larger in diameter and thus makes a more secure fit in some 0.020" (0.458-mm) receptacles. Probably the most inexpensive 0.020" (0.458-mm) receptacle available is the Molex Soldercon, which is sold in quantity by many dealers in the Electronics Marketplace in this magazine.

You might want to solder wire jumpers to appropriate points without using any receptacles at all. This can be done if you desire a permanent testing board for a specific IC type. You could even make one "deluxe" programming board with patch cords and receptacles for testing any TTL IC, and at the same time fabricate a number of prewired boards set up for frequently tested IC types.

Power supply construction is not critical. Point-to-point wiring is adequate. Connections from the IC tester to the power supply should be made directly at the voltage regulator's terminals. If the project is mounted in a plastic, rather than aluminum, enclosure, a heat sink must be provided for *IC12*. In any event, heat sink compound such as Dow Corning No. 340 silicone heat-sink compound should be used when mounting the IC on a heat dissipating surface.

Worst-case maximum power dissipation for the regulator will be approximately (in watts) the unregulated supply voltage minus five volts, because maximum current is about one ampere. The maximum dissipation of the regulator must be kept in mind when selecting the power supply transformer and heat sink. The rectified voltage across the filter capacitor will be about 1.4 times the rms voltage from the center tap to one end of the secondary in a full-wave circuit. If a bridge rectifier is used, the dc voltage across the filter capacitor will be about 1.4 times the rms voltage across the entire secondary winding (no center tap is needed). In any event, the unregulated dc applied to the input of *IC12* should never drop below 8 volts at full load. Otherwise the output will not be regulated. Also, the input to the regulator must not exceed 35 volts or the integrated circuit will be damaged.

Programming. All that's required to program the tester is patching input signals to the reference and test IC's. Each individual input of the test IC should be connected to a different binary code bit (*A* through *H*). In multiple section IC's, corresponding inputs can be wired in parallel. For example, when programming a test of a quad two-input NAND IC (SN7400), one input of each gate can be connected to the *A* output of the binary code generator and the other input of each gate to the *B* output. Thus there would be four gates with their inputs wired in parallel to the *A* and *B* bits.

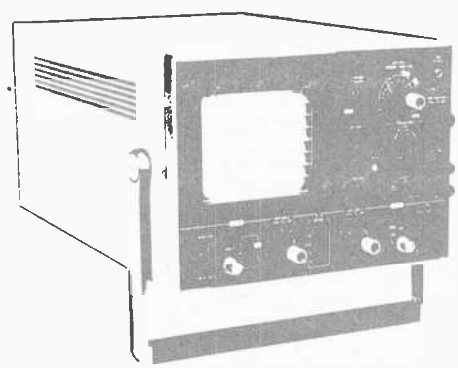
When specific binary code generator outputs (*A* through *H*) are patched to the test IC inputs, the corresponding separately buffered outputs *A'* through *H'* must be patched to the corresponding reference IC inputs. Programming is completed by patching +5 volts and grounds to the appropriate pins of both IC's.

The foil on the component side of the programming board is etched to provide clear labelling. Binary code generator outputs are boxed in and identified by the letters *A* through *H*. Separately buffered outputs are shown bussed together on the component side. This bussing is done for appearance's sake only and the programming receptacles need not be soldered on this side of the board. Actual bussing is done on the other side. Note, however, that the right-most receptacles in areas A, B and D must be soldered on both sides of the pc board.

The choice of which binary code outputs are used to drive either the reference IC or test IC inputs is unimportant so long as only one set (*A* through *H* or *A'* through *H'*) is used with one of the two IC's. The +5 volt supply is identified by a "+" and is shown bussed on the component side of the board. Similarly, the ground is so labelled and bussed. Again, this bussing on the component side of the board is for appearance only and the receptacles need not be soldered on the component side. But the right-most receptacles must be soldered on both sides of the board for proper connection to the power supply.

Receptacles tied to the test and reference IC sockets parallel each other along the edge of the board just above the edge connector contacts. They are labelled with pin numbers for 14- (in parenthesis) and 16-pin DIP's.

Two programming examples are shown in Fig. 7. It is desirable to make up similar programming sheets for each IC you test. Then you can use them as check-off sheets to verify proper programming and as a permanent record of the test program. Similar tests can then be performed at a future date by quickly referring to the appropriate programming sheet. ◇



GUIDE TO OSCILLOSCOPES

How to weigh the functions and performance that you need for your application in choosing this instrument.

BY CLAYTON HALLMARK

EVERYONE who gets into electronics, either vocationally or as a hobby, hopes to own an oscilloscope. This isn't surprising, considering that the scope is one of the most versatile test instruments ever to become available. Not only can an oscilloscope display a "picture" of the actual signal in a circuit under test, it can also measure the signal's amplitude, frequency, and time period.

The oscilloscope represents a sizable investment, but it is worth every penny you invest if you buy what you need and use it wisely. Here are some basic scope guidelines you should know before buying the instrument, including operating principles and specifications.

Curves and Measurements. The oscilloscope's usefulness in measuring time and voltage is illustrated in Fig. 1. Horizontal distances on the screen represent time by a fixed amount per graticule square, while vertical distances represent voltage, also by a fixed amount per square.

A TIME/DIV (typical) control on the scope can be used to set the width of the displayed image. The calibration markings on this control permit the elapsed time between any two points on the display to be determined by mutliplying the horizontal spacing in divisions by the numerical value of the TIME/DIV control setting. For example, the horizontal division between points A and B in Fig. 1 is five divisions. If the TIME/DIV setting is 100 μs/division, the elapsed time between A and B is $100\ \mu s \times 5 = 500\ \mu s$.

The VOLTS/DIV (typical) control on the scope is used to set the height of the display. The vertical distance tells the magnitude of the voltage of the displayed waveform in much the same manner as the horizontal distance tells the time be-

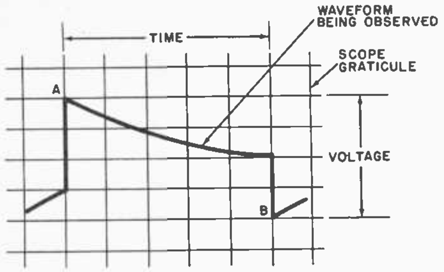


Fig. 1. Displayed waveform is plot of voltage versus time.

tween any two points. The voltage (vertical) difference between points A and B in Fig. 1, therefore, is four divisions. Now, if the VOLTS/DIV control is set to 0.5 volts/division, the voltage difference is $0.5 \times 4 = 2$ volts.

Basic Scope. A simplified diagram of an oscilloscope is shown in Fig. 2. Electron beam deflection is accomplished by controlling the charges on two sets of deflection plates within the CRT. One pair is for vertical deflection, and the other pair, mounted at right angles to the vertical plates, is for horizontal deflection of the beam.

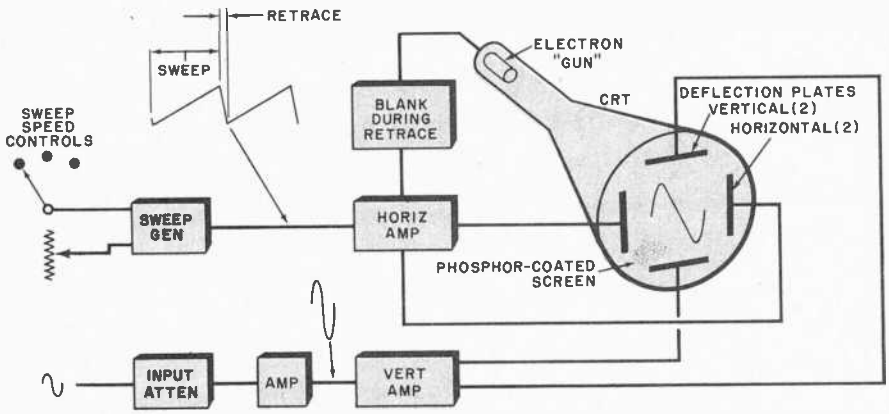


Fig. 2. Simplified diagram of how an oscilloscope works. Two sets of plates deflect the electron beam.

The horizontal sweep generator supplies a sawtooth waveform that is voltage amplified and applied to the two horizontal deflection plates. The amplified sawtooth waveform then forces the CRT electron beam to move at a uniform rate across the CRT phosphor-coated screen. The action of the electron beam impinging on the phosphor causes a dot of light to appear on the CRT, thus the horizontal sweep produces a line of light across the screen, which moves in a left-to-right direction.

When the sweep sawtooth reaches the "retrace" portion, it causes the electron beam to "snap" back to its origin (the left side) and await the start of another sweep. During this retrace interval, special circuits within the scope "blank" the electron beam so that it is not visible on the CRT screen.

During the relatively slow left-to-right progression of the electron beam on the CRT screen, whatever signal is applied to the vertical input is amplified and causes the CRT electron beam to be deflected up and down in step with the input signal. If the input signal is a steady dc voltage, the display is a straight line as shown in Fig. 3A. If one cycle of a sine wave, whose time interval is exactly the same as the sweep time interval, is used as the vertical input to the scope, the resultant CRT display will be a single sine wave (Fig. 3B). And, if the input sine wave time interval is only half of the sweep time, then two cycles of the input waveform will be seen on the CRT screen as shown in Fig. 3C.

Older, and inexpensive present-day scopes, have a SWEEP FREQUENCY control that permits the horizontal frequency to be adjusted to an exact submultiple of the vertical frequency. If this is not done, and if the starts of successive sweep ramps occur at different points on the input signal (positive peak, negative peak, start of positive alternation, etc.), the jumbled pattern shown in Fig. 4 results. In these "recurrent-sweep" scopes, the sweep signal voltage is generated by a sawtooth oscillator that is usually synchronized to the input signal by feeding it a sample of the input signal from the vertical circuits.

More modern and expensive oscilloscopes employ "triggered-sweep" instead of recurrent-sweep design (Fig. 5). The sweep generator is inactive until a trigger signal, derived from the input signal, starts it operating. When the input signal reaches the selected polarity and amplitude, the trigger circuit delivers a pulse to the sweep generator, which then produces *one* cycle of sweep. The sweep generator then "rests" until the input is again at the selected polarity and amplitude. If the input is a continuous sine wave, a continuous sawtooth is generated, as in a recurrent-sweep scope, but in sync with the input signal so that the display "stands still". If there is no input signal, no sweep occurs. Triggered-sweep scopes can be set so that they do not produce a trace in the absence of a vertical signal. Also, if the input consists of random pulses, the sweeps occur only when there are pulses.

Because triggered-sweep scopes use an extremely linear (with time) ramp, they provide an accurate way of measuring the time between events on a waveform. These scopes are thus said to use a "time base" instead of a horizontal oscillator. The time base's control is calibrated in *time/division* instead of *frequency*. In addition, the triggered-sweep scope provides a means for measuring small portions of pulse trains, random events, single events, and signals of rapidly changing frequency.

Recurrent-sweep scopes are far from extinct and certainly have their place today, especially where instrument cost

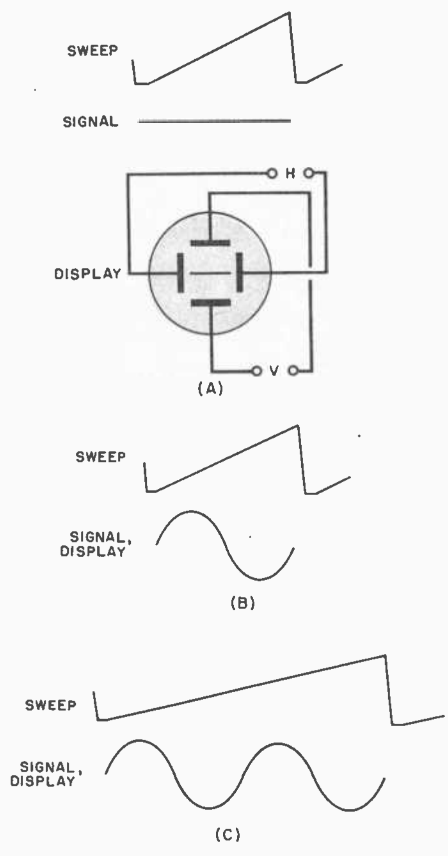


Fig. 3. Display depends on horizontal input and sweep.

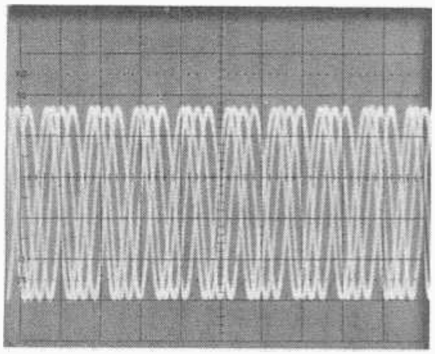


Fig. 4. Out-of-sync scope produces this meaningless pattern.

must be kept at a minimum. Aside from lower cost, the recurrent-sweep scope may be easier to use than the triggered-sweep scope. Some scopes even offer both types of sweep at the flip of a switch. (Providing both types of sweep are handy for establishing the baseline in the absence of an input signal.)

Two Scopes in One. Sometimes we are interested in measuring the time between events on two different signal paths. This can be done with a time-base (triggered-sweep) oscilloscope if there is a way of simultaneously displaying the two wave-forms. Many modern triggered-sweep scopes, therefore, have dual-trace capability to fill this need. With such a scope, the input and output waveforms (for example) of a circuit can be viewed at the same time and compared for time (phase) differences, distortion, and other differences.

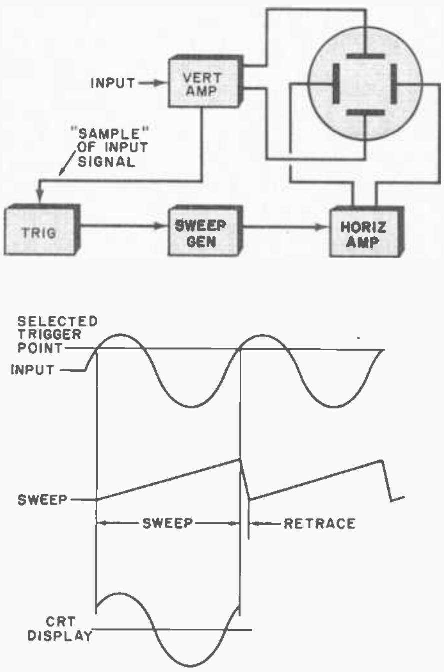


Fig. 5. Triggered-sweep scope and waveforms involved.

A dual-trace scope has two independent input channels that are fully controllable independently of each other, and whose electrical characteristics are carefully matched. The two signals are fed to the vertical-deflection plates via an electronic switch (Fig. 6).

The vertical amplifier circuit can be switched between the two channels in either of two ways. With the scope in its alternate mode, as in Fig. 6, switching occurs during sweep retrace; sweep one displays signal A, sweep two signal B, sweep three signal A, etc. The persistence of the CRT screen phosphor leaves an afterglow when a given trace is not being drawn causing the waveform to linger on the screen during alternate sweeps. Consequently, both waveforms appear to be displayed simultaneously. However, if the sweep rate is set sufficiently slow, as for viewing low-frequency signals, one waveform may begin to fade while the other is being traced on the CRT screen, and the display will flicker. This calls for the "chop" mode of operation.

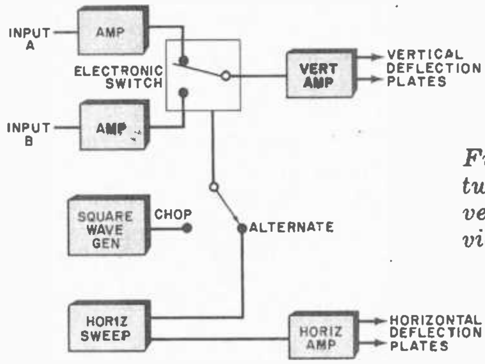


Fig. 6. In dual-trace scope, two signals are fed to vertical-deflection plates, via an electronic switch.

In the chop mode, a relatively high-speed square-wave oscillator alternates the electronic switch rapidly *during* sweeps. This produces a display such as that shown in Fig. 7. In practice, the traces are made up of so many segments that the integrating mechanism of the eye makes each appear as a continuous waveform.

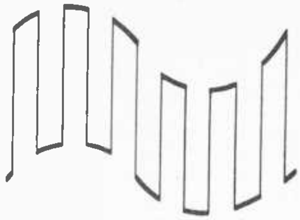


Fig. 7. Display with electronic switch in chop-mode operation.

Front-panel switches on dual-trace oscilloscopes permit selection of either the *alternate* or *chop* modes as desired. In a few scopes, the mode automatically changes from chop to alternate when a sweep speed of 1 ms/cm or slower is selected. This prevents flickering and speeds setup time when using the scope.

Some dual-trace scopes have a switch for exchanging the horizontal amplifier for one of the vertical amplifiers. In this XY mode of operation, the matched vertical amplifiers are used for both vertical (channel-A) and horizontal (channel-B) input signals. A plot of the Channel-A signal versus the channel-B signal results. One signal is plotted on the X (horizontal) axis, while the other is plotted on the Y (vertical) axis. Both signals are treated in the same manner by the amplifiers, and both can be measured in volts per centimeter (V/cm) by using the calibration controls.

A phase-relationship (or Lissajous) pattern appears on the screen when the scope is used in the XY, or "vectorscope," mode. One of the simplest loops to be obtained in this mode is shown in Fig. 8. The slant of the loop reveals the phase relationship of the signals. This mode can also produce a more complex loop, which looks like a "daisy" (Fig. 9), for checking the chroma circuits in a color-TV receiver. (A special CRT graticule is used with the daisy pattern to provide accurate color-TV receiver vectorscope

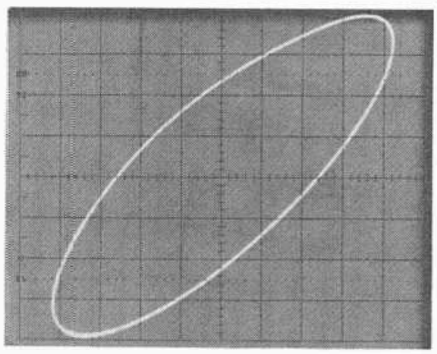


Fig. 8. Lissajous figures are used for phase measurements.

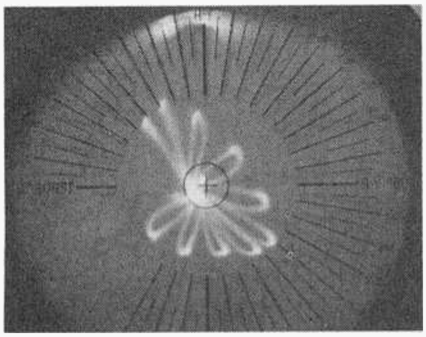


Fig. 9. Vectorscope pattern is useful in checking color TV.

operation.) Such a scope configuration can also "draw" the load line of a power supply or transistor.

Looking at Specifications. As with all electronic gear, and particularly electronic test equipment, it is important that you understand the various technical specifications used for oscilloscopes. Let us, therefore, list the various tech specs of a scope and explain what each means.

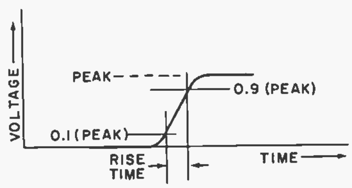


Fig. 10. Diagram shows how risetime of a wave is defined.

Frequency Response. The 3-dB-down frequency response, or bandwidth, of the vertical channel is the most important factor in the price and applicability of a given oscilloscope. The usable response of a scope just for radio work might not have to be greater than the audio range, but a TV repairman might need a scope that can display signals from 30 Hz to beyond 4 MHz. For more exhaustive and demanding tests, scopes with responses out to 10, 15, 50, or even 100 MHz might be required. Needless to say, you should select a scope according to the type of work you expect to be performing. You would not, for example, select a scope with a 100,000-Hz (100-kHz) range to do servicing on color-TV receivers. Conversely, a 100-MHz scope's range would be wasted if all you plan to work on is audio circuits.

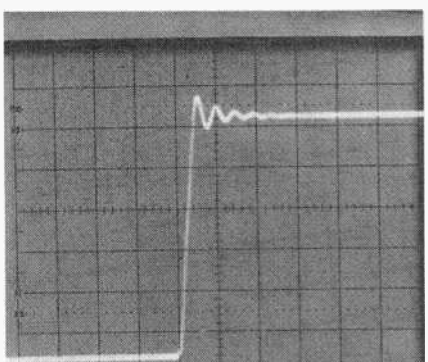


Fig. 11. Excessive overshoot caused by scope's poor response.

Risetime. Those of us who do a lot of work on digital circuits are particularly interested in the risetime of a scope. As illustrated in Fig. 10, the risetime of a pulse is the time it takes for the leading edge of a square wave to rise from 10% to 90% of its peak value. If, for example, it is necessary to measure within 3% a waveform risetime known to be in the 0.04-μs range, an oscilloscope with a risetime of not more than 0.01 μs would be required.

When comparing oscilloscopes, it is sometimes necessary to convert a specification from one form to another to determine how each scope measures up. If the bandwidth (BW) is known and you wish to know the risetime (t_r), or vice versa, just divide the known quantity into 0.35. The general formula is $BW \times t_r = 0.35$. Bear in mind, however, that this formula works only if the response of the scope rolls off smoothly, until it is close to 12 dB down at twice the −3-dB frequency. If the scope does not follow this Gaussian curve, excessive overshoot (more than 2% or 3%) occurs as shown in Fig. 11. If the scope does have a Gaussian response, it may be usable at frequencies up to twice the rated limit.

Deflection Factor. This is a measure of the oscilloscope's sensitivity or ability to display low-level signals. It indicates the signal amplitude required to cause the trace beam to be deflected one graticule division. The deflection factor is commonly given in millivolts peak-to-peak per division (mV p-p/div.). For some scopes, 10 mV/cm is common. Again, in comparing scopes, their specifications must be converted to a common term. If the voltage is given in rms, multiply by 2.828 to obtain peak-to-peak; if the division is 1", divide by 2.54 to obtain the centimeter equivalent.

Most modern scopes have adequate sensitivity. However, remember that, in comparing scopes, the lower the deflection factor, the easier it is to display low-level signals.

Accuracy. This is really calibration accuracy. It is comparable in meaning and percentage to the accuracy of an analog meter. Accuracy is generally in the range of 3% to 5%. The accuracy of the vertical calibration tells how closely the input voltage level can be measured, while the horizontal accuracy refers to the time (and frequency) measurements.

OSCILLOSCOPE MANUFACTURERS

B&K Precision, Dynascan Corp.
6460 W. Cortland Ave.
Chicago, IL 60635

Ballantine Laboratories, Inc.
Box 97
Boonton, NJ 07005

Dumont Oscilloscope Laboratories, Inc.
40 Fairfield Pl.
W. Caldwell, NJ 07006

Eico Electronic Instrument Co., Inc.
282 Malta St.
Brooklyn, NY 11207

Heath Company
Benton Harbor, MI 49022

Hewlett-Packard Co.
1501 Page Mill Rd.
Palo Alto, CA 94304

Hickok Electrical Instruments
10514 Dupont Ave.
Cleveland, OH 44108

Leader Instrument Corp.
151 Dupont St.
Plainview, NY 11803

Lectrotech Inc.
5810 N. Western Ave.
Chicago, IL 60659

Philips Test and Measuring Inst. Inc.
400 Crossways Park Dr.
Woodbury, NY 11797

Sencore Inc.
3200 Sencore Dr.
Sioux Falls, SD 57107

Systems Electronics, Inc.
9727 Inglewood Ave.
Inglewood, CA 90301

Telequipment Div. of Tektronix
Box 500
Beaverton, OR 97005

VIZ Manufacturing Co.
335 E. Price St.
Philadelphia, PA 19144

Vu-Data Corp.
7170 Convoy Ct.
San Diego, CA 92111

Impedance. The input impedance of an oscilloscope is usually a 1-megohm resistance shunted by a 30-pF capacitance. (Most laboratory-grade scopes have 50-ohm input impedances.) The input impedance with a probe is typically 1 megohm shunted by 20 pF for a low-capacitance probe. To prevent circuit loading, a low-capacitance probe is desirable. Some scopes have switch-selectable input impedance: 1 megohm for general use with a probe and 50 ohms for pulse and CW measurements in low-impedance circuits.

Most oscilloscopes can tolerate up to 500 volts peak-to-peak at their inputs without suffering damage. However, if you plan to be working with higher voltages, we strongly suggest that you invest in a 5-kV or higher probe. The maximum voltage that can be measured by an oscilloscope depends on the instrument's voltage rating, availability of a high-voltage probe, and the scope's maximum deflection factor.

Sweep Rate. The number of cycles in a display is equal to the signal frequency divided by the sweep rate. If you link up a wideband vertical amplifier and a low-performance sweep generator, the waveform displayed will be highly distorted.

For best results, you want no more than about six cycles of signal displayed. Hence, for TV work, you need a sweep speed of at least 500 kHz, which would yield about seven cycles of the 3.58-MHz color oscillator signal. A sweep of only 100 kHz would put no less than 35 cycles on the CRT screen.

To determine how many cycles of a given frequency a triggered-sweep scope will display at its fastest sweep rate, the time/division specification must be converted to frequency using the formula $f = 1/(t/div \times W)$, where t/div is the lowest sweep setting and W is the width of the screen. A sweep rate of 0.2 μs/cm on a screen 10 cm wide corresponds to a 500-kHz sweep rate. For many scopes, the maximum sweep rate, rather than the bandwidth of the vertical amplifier, will determine the maximum high-frequency operating point.

Sweep Magnifier. This handy feature allows the display to be expanded, or magnified, vertically by operating a switch. Typical expansion factors are ×2, ×5, and ×10. Either or both ends of the trace then go off the screen, and the portion of the trace that is desired to be examined can be positioned on-screen. In effect, the sweep magnifier increases the maximum sweep rate of the scope. If a scope has a top sweep rate of 0.1 μs/cm, with ×5 magnification, the top rate becomes 0.02 μs/cm.

The sweep magnifier allows display of part of a pulse train that occurs much later than the triggering signal. It also allows complex signals to be spread out for close examination.

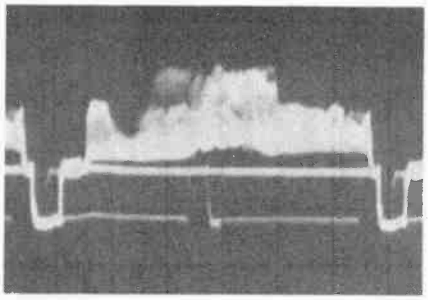


Fig. 12. Scope display having TVV and TVH modes of operation.

TVV and TVH Modes. Some time bases in oscilloscopes have two preset positions for TV vertical and TV horizontal waveforms. The positions, usually labelled TVV and TVH, correspond to the television vertical and horizontal sync rates of 60 Hz and 15.75 kHz (sometimes 7.875 kHz). With this feature, viewing the composite video signal (Fig. 12) is greatly simplified.

Alternate vs. Direct Coupling. In essence, a dc scope has a vertical amplifier system that will respond all the way down to the dc level, and thus display the input waveform exactly as "seen" by the scope input. In this mode, the scope can also be used as an accurate dc voltmeter.

An ac scope is simply one in which there is a blocking capacitor in the input circuit (and possibly elsewhere in the vertical amplifier system) so that the amplifier will not respond down to the dc level. Although a scope is used most often on ac signals, sometimes these signals are found "riding" on a dc level, as at the plates of vacuum-tube amplifiers, where the ac signal of interest can be as much as 250 volts dc above ground. Obviously, if this composite signal is fed to a dc scope, the trace will disappear off the screen, and it may be very difficult to bring into view. Therefore, an ac scope is handy when you have to examine signals that ride on some relatively high dc level.

Since an ac scope will not respond to dc signals, the reactance of the capacitor limits the lower-frequency response and that is why ac response is usually specified as from 1 or 2 Hz up. Ac coupling also means that steady-state dc signals, such as those forming the tops and bottoms of square waves will have a "droop" that is not present on the original signal. It also means that ac scopes cannot be used as dc voltmeters. To get the most of both approaches, purchase a scope having both ac and dc coupling.

Probes. An oscilloscope is effective only when it can be interfaced with a circuit that requires waveform analysis, and this is where probes come in.

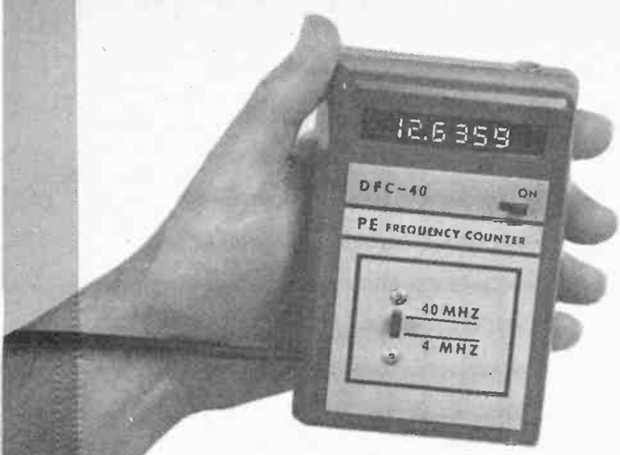
There are several types of probes, each designed for a specific purpose. They range from simple coaxial-cable types with test prods at the ends, through input impedance multipliers, to r-f probes that can be used to examine signals operating at many hundreds of megahertz.

The simplest probes are lengths of coaxial cable with one end terminated in a suitable scope input connector and the other end fitted with alligator or plastic encased test prods. The grounded braid of the cable reduces any noise pickup.

Input impedance multipliers are usually specified with a ratio—10:1, for example—which means that you can look at signals whose voltage levels may be greater than the maximum voltage sensitivity of the scope. It also means that the scope input impedance is raised by a similar factor. This can be important when making measurements in very high-input-impedance circuits (such as CMOS) to avoid loading problems.

The use of an r-f-demodulator probe does *not* extend the scope bandwidth to the probe limits (which may be 250 MHz). Such a probe can be used to *demodulate* a signal from an r-f carrier up to the probe limits. Using such a probe, the modulation of a CB, ham, or business radio can be easily examined for modulation characteristics, as long as the modulation frequency does not exceed the demodulation limits of the probe or the response of the scope.

Summing Up. An oscilloscope may be the most sophisticated instrument you ever buy. Choosing a particular one from the many makes and models on the market is not easy. The best advice to follow is to decide "how much" scope you need and how much money you are willing to invest. Then compare specifications. Give serious consideration to your needs. Vectorscope capability and TVV and TVH features would mean more to a TV service technician than an electronics hobbyist, for example. For serious experimenting, do consider dual-trace capability, triggered sweep, and sweep magnification. ◇



A 40-MHz FREQUENCY COUNTER

Portable counter features six-digit LED display and 10-Hz to 100-Hz resolution.

BY BILL GREEN

OWNING a frequency counter is no longer a luxury. For electronics experimenting and for servicing today's equipment, one needs this piece of test gear to count clock rates, adjust oscillators, and so on. Here's a handy, low-cost, portable counter that can serve admirably for these purposes.

It will count from less than 100 Hz to more than 40 MHz and display the input signal's frequency on a six-digit, multiplexed LED display. The counter uses CMOS and low-power Schottky IC's, bipolar transistors and a FET, allowing operation from alkaline and rechargeable Ni-Cd batteries.

About the Circuit. The frequency counter is illustrated schematically in Figs. 1 and 2. Input signals are coupled by *C1* to transistors *Q1* and *Q2*, which comprise a unity-gain buffer with a high input impedance. Diodes *D1* and *D2*, together with *R3*, protect the buffer from excessive input signal levels. A 10,000-series ECL triple line receiver, *IC1*, amplifies the voltage developed across *R5*. The third stage of this IC is used as a Schmitt trigger to square up the signal waveform. The output of *IC1* is applied to *Q3*. A TTL-compatible version of the input signal is available at the collector of this transistor. Hot-carrier diode *D3* is placed across the collector/base junction of *Q3* to prevent saturation, thus keeping the transistor's switching speed high.

Depending on the position of *S2*, (see Fig. 2), the output signal from *Q3* is applied to either *IC2* or *IC5*. When the switch is in the 4-MHz position, the signal is routed to *IC5*, an inverting buffer. When *S2* is placed in the 40-MHz position, *IC2*, a divide-by-10 prescaler, is inserted. The output of *IC2* is then buffered by *IC5*. Switch S2 performs two other functions. The second switch pole passes current to the appropriate decimal point on display *DIS1*. The third pole selects one of two pull-up resistors (*R22* or *R23*) for the open-collector output of *IC5*. These resistors, along with *C14*, provide additional signal conditioning before the waveform is applied to CMOS counter *IC4*. This LSI chip contains all the circuitry necessary for counting, latch, decode and drive functions, and interfaces directly with the display.

Integrated circuit *IC3* is the master clock. It consists of a crystal-controlled oscillator running at 6.5536 MHz and several dividing counters. Among its outputs are a 1600-Hz multiplex control signal and reset and gating pulses for *IC4*. Supply voltages of +5 and +10 volts are required. In the author's prototype, they are derived from series strings of four AA Ni-Cd and three AAA alkaline cells. Jack *J1* is used with an external charger, and R_X is chosen to limit charging current to a safe value. Power supply bypassing is performed by *C3, C4, C5* and *C13*.

Construction. Suitable etching and drilling and parts placement guides are shown in Fig. 3. Begin by installing the six jumpers on the pc board. Then install IC sockets or Molex Soldercons, followed by the resistors. Mount all fixed capacitors on the component side of the board, except for *C6* and *C13*. These capacitors and trimmer *C12* are installed on their sides on the foil side of the

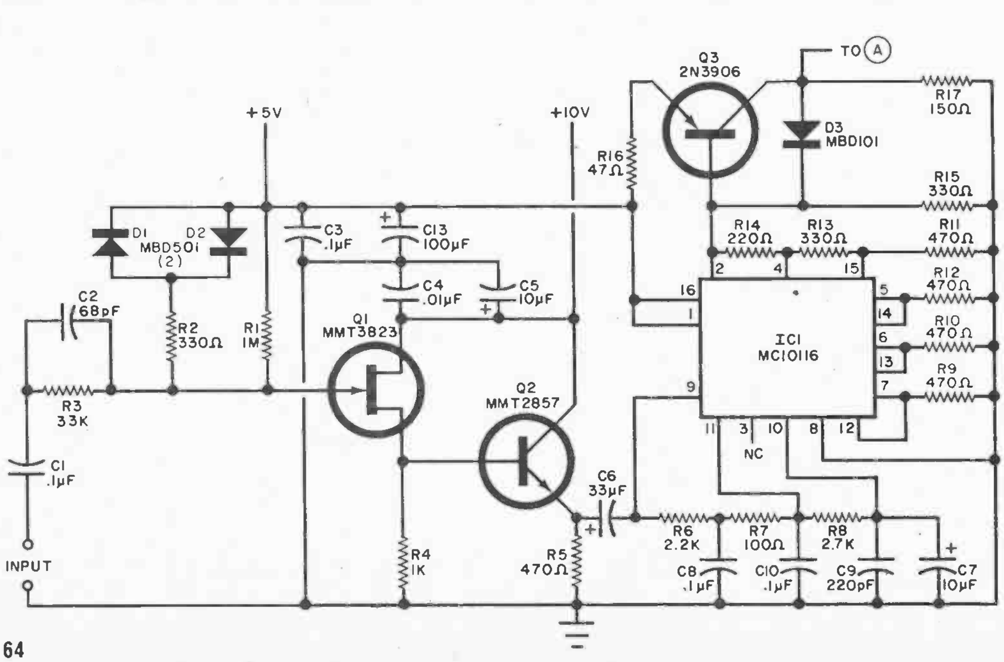
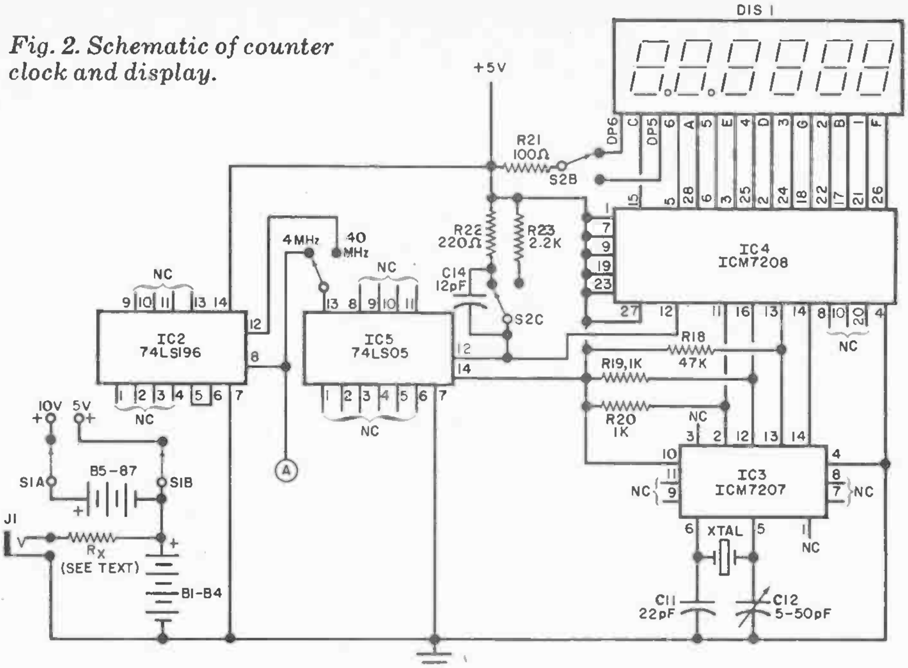


Fig. 1. Schematic diagram of counter's input stage.

PARTS LIST

B1 through B4—AA Ni-Cd cell
B5 through B7—AAA alkaline cell
C1,C3,C8,C10—0.1-µF, 600-V disc ceramic capacitor
C2—68-pF disc ceramic or silver mica capacitor
C4—0.01 µF disc ceramic capacitor
C5,C7—10-µF, 16-volt tantalum capacitor
C6—33-µF, 16-volt tantalum capacitor
C9—220-pF disc ceramic or silver mica capacitor
C11—22-pF disc ceramic or silver mica capacitor
C12—5-to-50-pF trimmer capacitor
C13—100-µF, 16-V electrolytic capacitor
C14—12-pF disc ceramic or silver mica capacitor
D1,D2—MBD501 diode
D3—MBD101 diode
DIS1—Multiplexed LED display (see note)
IC1—MC10116 ECL triple line driver IC
IC2—74LS196 Schottky decade counter IC
IC3—ICM7207 LSI CMOS oscillator/divider IC (Intersil)
IC4—ICM7208 LSI CMOS counter IC
IC5—74LS05 Schottky inverting buffer IC
J1—Suitable jack for battery charger
Q1—MMT3823 n-channel FET (Motorola)
Q2—MMT2857 npn silicon transistor (Motorola)
Q3—2N3906 pnp silicon transistor
The following resistors are ¼-watt, 10% tolerance.
R1—1 megohm
R2,R13,R15—330 ohms
R3—33,000 ohms
R4,R19,R20—1000 ohms
R5,R9 through R12—470 ohms
R6,R23—2200 ohms
R7,R21—100 ohms
R8—2700 ohms
R14,R22—220 ohms
R16—47 ohms
R17—150 ohms
R18—47,000 ohms
S1—Dpst switch
S2—3pdt switch
XTAL—6.5536-MHz quartz crystal
Misc.—Suitable enclosure, batteries and charger, battery holder, magnifying lens, solder, hook-up wire, IC sockets or Molex Soldercons, shielded cable, suitable probes, machine hardware, epoxy cement, electrical tape, etc.
Note—The following are available from Alpha Electronics (Texas), Box 64726, Dallas, TX 75206: Kit of parts and case (No. DFC-40) less input cable and probes, batteries and battery holder: $50.00 plus $3.00 postage and handling. Parts also available separately: 6.5536-MHz crystal, $7.50 postpaid; etched and drilled printed circuit board (No. 280776) $8.50 postpaid; DIS1 display (No. AE-9), $6.00 postpaid; Bag of semiconductors including D1 through D3, IC3, IC4, Q1 and Q2, $35.00 postpaid.

Fig. 2. Schematic of counter clock and display.



board. Observe polarities on all aluminum and tantalum electrolytic capacitors. The remaining fixed capacitor, *C14*, is mounted on the lugs of *S2*. Quartz crystal *XTAL* is installed on the foil side by bending its leads 90° and inserting them into the holes on the board. Be sure the body of the crystal clears the foil under it before soldering.

Mount diodes *D1, D2, D3* and transistor *Q3* on the board, paying close attention to basing. The MMT transistors (*Q1* and *Q2*) are soldered to the foil side of the board. Note that these transistors are color coded. Install *Q1* so that its yellow dot is on the foil side and *Q2* so that its orange dot is on the component side of the board.

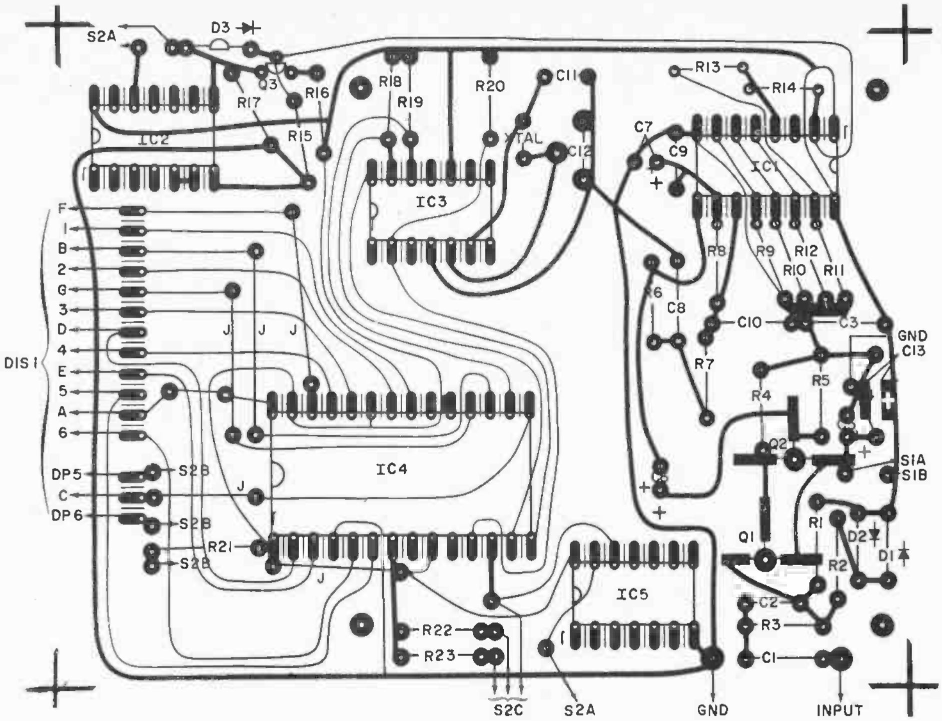
The display assembly must be prepared before installation. Orient the assembly so that the numbers etched on the component side are toward you. Cut the cathode leads (the third from the left or middle lead on the bottom of the displays) of digits 1, 2 and 9 at the displays and unsolder them from the board. Cut the DP (decimal point) lead (fifth from the left at the bottom of the displays) at the board—not the displays—of digits 3 and 4 *only*. Clear the solder from the holes where the cathode leads of digits 1 and 2 went through the board. Run a short length of insulated wire from the hole where digit 1's cathode lead was connected to the decimal point lead of digit 3. Then repeat this procedure for the DP lead of digit 4 and the cathode hole for digit 2.

From now on, refer to digit 8 as denoted by the etched numeral as digit 1, digit 7 as digit 2 . . . and digit 3 as digit 6. Solder a straight pin into each display board hole except the fourth from the left and right-most holes. The pin heads should be flush with the component side of the display pc board. Place the display board over the main board and insert the pins into the holes in the main pc board. Space the boards 5/16" (8 mm) apart and solder the pins to the main board. Clip the excess pin lengths from the foil side of the main board. Bend the display assembly so that it is at a 15° angle to the main board. When the counter is installed in its case, the display will be aligned for centered and properly magnified digits.

Bend the lugs of *S1* and *S2* 90° and connect them to the pc board with short lengths of insulated hook-up wire. With *S1* in the OFF position, wire four AA Ni-Cd cells in series between ground and *S1B*. Also connect a battery holder for three AAA alkaline cells between *S1A* and *S1B*. Wire a suitable charger jack to ground and to *S1B* via resistor R_X. Select the value of R_X to prevent (if necessary) your battery charger from overcharging the batteries. Connect the charger to *J1* and allow the batteries to charge.

Install the IC's, following the standard precautions for handling MOS devices. Apply power by closing *S1*. Digits 1 and 2 (at the least) should light. Apply a 200-mV signal at 4 MHz or less across the counter input. With *S2* in the 4-MHz position, check for a stable and accurate reading. Repeat this procedure with *S2* set to 40 MHz and a 200-mV signal at 40 MHz or less.

Cut a display magnifier to size and install it in the counter's enclosure with epoxy cement. Mount *S1* and *S2*. Install the pc board so that the display is properly centered and aligned. Then drill holes for *J1* and the input cable. Insulate the batteries and the battery holder with electrical tape to prevent accidental shorts. Select suitable cable or wires for the input lead. Coax such as RG-58/U can be used, but its impedance is low and will tend to load down high-imped-



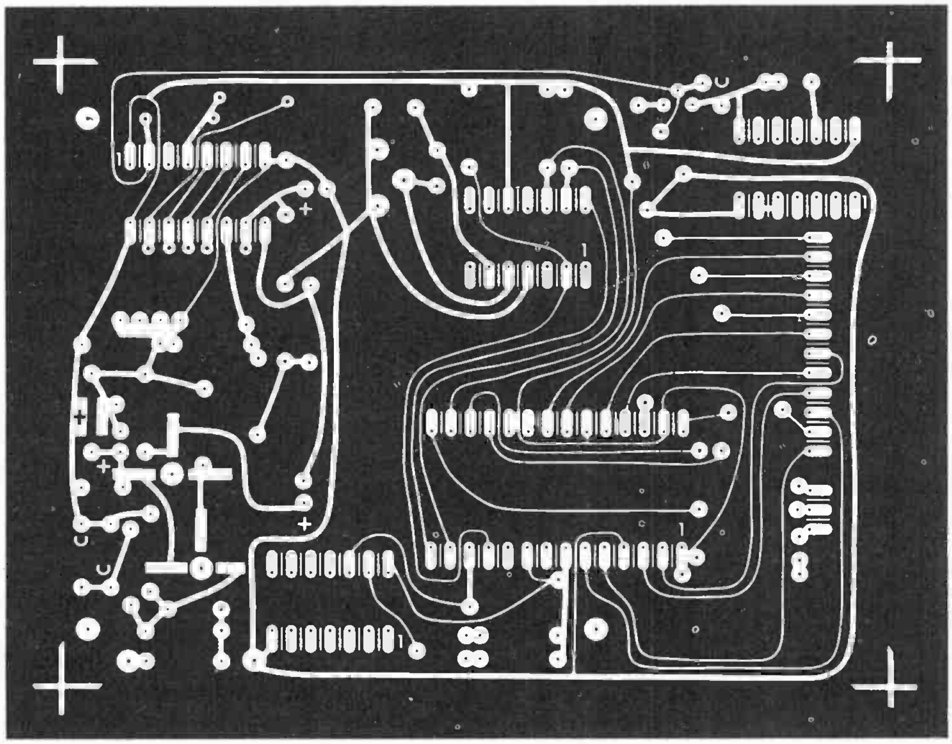


Fig. 3. Etching and drilling guide for pc board (left) and component layout (above).

ance circuits. Two separate shielded leads will work well and exhibit less of a loading effect. Solder the input lead(s) to the foil side of the pc board and run it (them) out through the hole in the enclosure. Mount *J1* and place the alkaline cells in their holder.

Calibration. If a frequency counter or frequency standard is available, calibration can be performed merely by connecting a signal source of known frequency to the counter input and adjusting *C12* for an accurate reading. If no standard or counter is available, a signal generator can be zero-beat against WWV and used as a reference. The counter's accuracy can approach or exceed 0.00001%, depending on calibration accuracy.

Using the Counter. The sensitivity of this counter is nominally 200 mV from 100 Hz to 40 MHz. Operation beyond these limits is possible if greater input levels are applied. Keep in mind that the input stage is protected to 50 volts. If the counter is to be used with an r-f transmitter, a short length of heavy, insulated wire may be used as an antenna to measure the output frequency. A ground is not required in this mode of operation. Frequencies will be displayed with 10-Hz resolution in the 4-megahertz range, and 100 Hz in the 40-megahertz range. ◇

ACCURATE MILLIAMMETERS ON A BUDGET

How to modify surplus-type meters to obtain high accuracy.

BY DAVID CORBIN

Buying an ammeter with built-in shunts to measure currents from milliamperes to hundreds of amperes can be an expensive proposition. It is much less costly to obtain a basic 1-mA movement and add the shunts you need to create the necessary ranges. This can be done by using the table supplied here. It tells you what shunt values are required for a given milliammeter movement with a 1-mA full-scale swing.

About Accuracy. Depending on the movement you choose and how much you pay for it, basic accuracy will be between 1% and 5% full-scale. The accuracy figure is loosely based on both repeatability and scale precision. Bear in mind that the accuracy of large panel meters is generally no better than 1% full-scale. What these movements offer for the high prices they command are ruggedness, long life, temperature compensation, magnetic shielding, and high breakdown voltage, all of which may be important in some applications. Where the application is not critical, you can choose a small $3.50 to $6.00 panel meter and get more than adequate results.

When you look at accuracy figures for basic meter movements, be sure you understand the meaning of the figures. Since a current-measuring meter is placed in series with the source and load, it should have the lowest possible resistance for maximum sensitivity. The meter's resistance is a part of the circuit and affects the overall flow of current.

Let us assume that you have two meters, one with a 50-ohm resistance and the other with a 100-ohm resistance. If you were to insert the 100-ohm meter into a circuit with 100 ohms resistance in which the actual current flow is 1 mA, the meter would indicate 0.5 mA. Substituting the 50-ohm meter would yield a 0.67-mA reading. The readings obtained are the actual currents flowing in the circuit *while the meters are in the circuit* and they are within 1% of the actual current. (Of course, if you remove the meters, the current in the circuit would again become 1 mA.) The discrepancies are the result of the fact that the meters add their own resistance to the circuit and reduce the overall current flow.

If the meters had zero resistance (impossible to achieve in practice), they would not affect the flow of current. In this case, both meters would indicate 1 mA. It is obvious then that, in the world of real measurements, you must take into account the effect the meter has on the circuit that is being tested.

Custom Tailoring. Since the voltage it takes to swing the milliammeter's pointer to full-scale is the product of full-scale current times coil resistance, it is easy to design circuits and make reference charts for choosing shunt and series-shunt combinations. It is amazing how small a voltage is required for a full-scale pointer swing on a typical 1-mA movement. For example, a 50-ohm, 1-mA movement requires 1 mA × 50 ohms, or 50 mV (0.050 V) full-scale.

The problem is that many low-cost meter movements are provided with no specifications other than the scale markings. You cannot measure the coil resistance with an ohmmeter because the test voltage is much too high and can damage the movement or burn out the meter's coil. The best way to check milliammeter movements is with a simple meter calibration circuit like that shown in Fig. 1. For this, you will need a good standard multimeter capable of indicating current to 1 mA full-scale. (Even a $6 basic movement will do if its coil resistance is specified.)

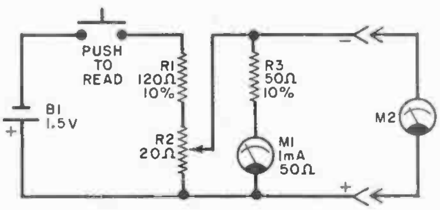


Fig. 1. Here is a simple meter calibration circuit you can use to check meter movements.

The meter calibrator shown in Fig. 1 uses a 50-ohm movement. This movement indicates half of the voltage dropped across tested movement *M1*. The total reading from *M2* is read as 0 to 0.1 volt or as 0 to 100 ohms. Potentiometer *R2* is adjusted for a full-scale reading on *M1*.

Once you know coil resistance R_M and full-scale voltage E_M, as indicated on *M2*, you can calculate the shunts needed to increase the basic movement's range. The formula for this is $R_S = E_M/(I_D - I_M)$ where R_S is the shunt resistance in ohms and I_D and I_M are the design and movement's full-scale currents in amperes. However, to avoid having to perform the mathematics, you can refer instead to the table, which gives the values of the shunt resistors needed for various 1-mA meter movements for a variety of full-scale ranges. The resistances in the table are rounded off to three places in most cases. It isn't necessary to be too accurate in shunt-resistor selection because of the limitations resulting from the built-in errors of the basic meter movement itself.

About the best possible accuracy you will be able to obtain, no matter how precise the values of the shunt resistors, will be 1% of the full-scale reading. The resistors you use will not normally be better than 1% to 5%, and the meter movement itself cannot be interpreted to better than 1% accuracy even if it is the best available.

The 1-mA movement will probably be calibrated in 10 major divisions, with five minor divisions between each. This works out to 0.1-mA major and 0.02-mA minor steps when only the basic measuring range of the movement is considered. When multiplied by the shunt factor for a 50-mA full-scale reading, the major steps are each 5 mA and the minor steps are each 1 mA. However, without an antiparallax mirror backing on the movement and other refinements, one minor division is about the limit of what you can interpret on any reading.

Thus, a 1-mA error is possible in the reading and 0.5 mA in the meter's basic accuracy. In terms of a shunt, assuming a 50-ohm movement, this is like using a 1-ohm resistor instead of the required 1.02 ohms. In fact, the difference of 0.5 mA caused by the movement itself would be the same as an error of from 1.0098884 to 1.0309278 ohms instead of the exact 1.0204081 ohms required.

SHUNTS NEEDED FOR VARIOUS MOVEMENT RESISTANCES AND FULL-SCALE CURRENT

	Shunt (ohms)				
Movement (ohms)	12.5	25	50	75	100
Current (mA)					
5	3.13	6.25	12.5	18.75	25.0
10	1.39	2.78	5.56	8.33	11.1
25	0.52	1.04	2.08	3.13	4.17
50	0.26	0.51	1.02	1.53	2.04
75	0.17	0.34	0.68	1.01	1.35
100	0.13	0.25	0.51	0.76	1.01
150	0.08	0.17	0.34	0.50	0.67
200	0.06	0.13	0.25	0.38	0.50
500	0.025	0.05	0.10	0.15	0.20
1000	0.0125	0.025	0.05	0.075	0.10
10,000	0.00125	0.0025	0.005	0.0075	0.01

This simply points out the limit of accuracy to be expected with *any* moving-coil type of meter. Needless to say, the home-built metering circuit can be as accurate as the best commercial analog meters.

To avoid having to wind special resistors, you can use combinations of standard resistor values to make the required shunts because the precision required for good results will not be excessive. The formula for determining the value of the parallel resistor needed for a given shunt value and given one resistor of known value is $R_U = R_S R_K/(R_K - R_S)$, where R_U is the resistance to be found, R_S is the desired shunt resistance, and R_K is the value of the known resistor. To obtain a good many values with odd decimal endings, a fractional value resistor can be used in series with a standard larger value resistor. Of course, the accuracy will suffer when the possible errors of the resistor values are added to the circuit. However, if you use 1% and 5% tolerance resistors and the scale multiplication is large, the amount of overall error will be in the same range as the limits of the meter movement itself and will not have much effect on the accuracy of the reading.

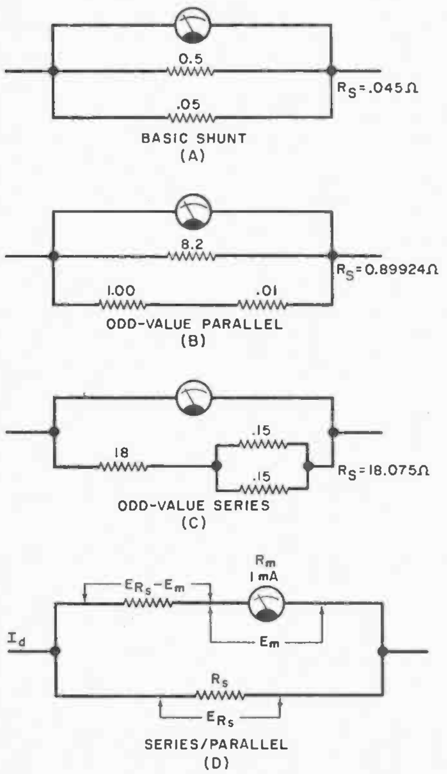


Fig. 2. Various configurations for using shunts with meters.

The power that is generated in the shunt must be handled without excessive heating of the shunt or the values of the shunt resistors will change. By using resistors with 50% greater heat dissipation (power rating) than is actually required, you will not exceed safe limits. Even with a 10-ampere shunt, the current is not large enough to generate much heat in a 0.01-ohm load. The power generated will be 1 watt, so a 2-watt resistor will be more than adequate. Smaller currents develop correspondingly lower power in the shunts. The formula for calculating the power rating of the shunt resistors is $P = 1.5E_M (I_D - 0.001)$, where P is the power in watts, E_M is full-scale meter voltage in volts, and 0.001 is the value of the 1-mA meter movement's full-scale current.

To measure higher currents without having to resort to very small values of resistors and resistor combinations for the shunts, a dropping resistor can be placed in series with the meter movement. (Various configurations of shunt circuits are shown in Fig. 2. The Fig. 2D circuit illustrates the resistor placed in series with the meter movement.) If you know the value required for shunt resistor R_S, the formula for determining the value of dropping resistor R_D is $R_D = [R_S(I_D - 0.001) - E_M]/0.001$, where R_D is in ohms, I_D is in amperes, and 0.001 is the full-range current of the meter movement. To find R_S when the total drop is specified, use the formula $R_S = E_{RS} / (I_D - 0.001)$. Then $R_D = (E_{RS} - E_M)/0.001$.

The Fig. 2D circuit can be used when a certain voltage drop is required in a metering circuit and it is different from the drop that would result from using a standard shunt circuit. It is also handy for avoiding small values of resistance, but the pitfall is excessive power loss through the shunt when measuring high currents.

The power in the shunt is calculated by subtracting 1 mA from the design current (I_D) and multiplying this times the voltage drop across the shunt, which is the same as the total circuit drop. Almost any value of resistance can be used for the shunt, but the power rating will go up in direct proportion to the resistance for any given current measurement. The biggest advantage will be in the avoidance of odd-value shunt resistors that cannot readily be obtained by connecting resistors in parallel or series-parallel configurations.

Multirange general-purpose meters can be made by using a combination of simple shunt and series-shunt networks and a multi-position switch. The lower ranges, where shunts are obtainable in close-to-standard values, can have the shunts switched directly across the meter movement.

Summing Up. The design of current-measuring circuits in which a standard 1-mA meter movement is used is applicable to even the most limited budget and available test equipment. It provides accurate current monitoring in up to four decade ranges at a typical cost of less than $15. A single-value monitor circuit can be installed in a project for less than $9, and it will provide an accuracy of between 1% and 5% full-scale, depending on the care taken during the design stages. The problem of finding and stocking a variety of current meters is solved by keeping one or two milliammeter movements handy and making up a few standard shunt circuits to use with them as described here. ◇

How Computers Detect and Correct Transmission Errors

Parity checking and redundancy are two of the devices used in error detection.

BY JEROME MAY

ALMOST everyone has had some experience in dealing with a computer mixup. One classic story goes like this: a computer, doing one of the earliest payroll jobs, put a 1 where a zero should have been, and the next week the janitor picked up his paycheck for exactly $1,000,147.38!!

Systems engineers and serious microprocessor hobbyists are aware of the problems that random noise can cause on data lines. Noise can cause the "three" that was sent to show up as a "seven."

Because "error" can be treated as a random event, having equal likelihood of occurring in any given datum, it becomes possible to apply techniques of *information theory, probability,* and *statistics* toward designing systems that are resistant to this type of error.

A simplifying assumption that will be useful is that, in a data word consisting of *n* bits, only *one* bit will be in error. The treatment of multiple-error-detecting systems uses methods similar to those discussed, but the treatment becomes extremely mathematical and complicated and is beyond the scope of an introductory article.

DECIMAL	BINARY	BCD	EXCESS-3	GRAY CODE	DECIMAL
0	0000	0000	0011	0000	0
1	0001	0001	0100	0001	1
2	0010	0010	0101	0011	2
3	0011	0011	0110	0010	3
4	0100	0100	0111	0110	4
5	0101	0101	1000	0111	5
6	0110	0110	1001	0101	6
7	0111	0111	1010	0100	7
8	1000	1000	1011	1100	8
9	1001	1001	1100	1101	9
10	1010	xx	xx	1111	10
11	1011	xx	xx	1110	11
12	1100	xx	xx	1010	12
13	1101	xx	xx	1011	13
14	1110	xx	xx	1001	14
15	1111	xx	xx	1000	15

Fig. 1. Five different 4-bit codes for the decimals 0 through 15.

Redundancy. An error can be detected by redundancy, which is the inclusion of extra information with each data transmission. This extra information helps the receiver to decide if the data it has received has been altered in transmission.

Obviously, the simplest error detecting system, conceptually, would be the transmission of each data unit twice. Thus, if the first transmission does not match the second transmission, the receiver can signal that an error has occurred and to please repeat the data.

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Restating the problem, the decimal

numbers 0 through 15 have exactly 16 representations in binary, as shown in Fig. 1. Since all possible combinations of 0 and 1 in four positions are used, there is no way to detect datum error because all combinations are equally likely; there is no room for redundancy.

Binary-Coded Decimal. Suppose only the decimal digits, 0 through 9, are to be transmitted. From these 10 digits any positive decimal integer can be constructed. The 10 binary representations for these digits are known as *binary-coded decimal*, or BCD.

In BCD the codes for the numbers 10 through 15 decimal are not used and, if they show up at a receiver, they can be detected as "illegal" by checking the received datum with a "legal word" list. By selecting BCD over straight binary, a designer makes it possible to detect one type of error.

Excess-Three Code. By making a simple change to the code, more information—redundancy—can be built right in. The *excess-three* (X-3) code is obtained by adding binary 0011 to the BCD codes for the decimal digits 0 through 9. Figure 1 shows that X-3 does not allow the codes 0000 or 1111. Thus, every legal X-3 word contains at least *one* 0 and 1, providing another bit of information—that the data channel is active and transmitting.

Another property that makes it interesting for error-checking is that X-3 is a *self-complementary* code. That is, if each 0 of a legal X-3 word is changed to a 1, and each 1 to 0, the process generates the 9's complement of the word. This feature makes error-checking in X-3 easier and statistically more reliable than BCD codes. In a BCD error-checking algorithm, for example, a minimum of *six* comparisons and table look-ups must be made before an error can possibly be detected.

BCD is a *weighted positional* code; in which the position of each bit in the data word determines its value. X-3 is not a weighted positional code. By counting 1's and 0's in each position of the X-3 representation of the digits 0 through 9, it can be seen that for a given X-3 word, each position has a 50% probability of being either 0 or 1. This eliminates any statistical bias in the code itself.

In an X-3 error-checking algorithm, with judicious use of the "complement" function (a very fast and very easy operation in most microprocessors), the algorithm can detect a bad code in six comparisons but only *two* memory look-ups. In some cases, the error checking can be done 100% *faster* by use of the X-3 code for data transmission.

As a further bonus, the X-3 code makes keeping track of carries and borrows in addition and subtraction of coded decimal digits significantly simpler than in the straight BCD code.

Gray Code. Turning to a completely different four-bit code, the *Gray code* finds an application in many analog-to-digital data-transmission systems. The Gray code's most significant feature is that, going from one number to another with a difference of only one, only a single bit changes in the Gray code. In a system where the analog signal is expected to change slowly with respect to the sample frequency (say, for example, temperature inside a house is being monitored and encoded), a change in more than one digit position would automatically signal an error to the receiver.

Some information—more redundancy—about the data itself is reflected in the code itself. The odd decimal digits (1, 3, 5 etc.) have Gray-code equivalents that contain an *odd* number of 0's and 1's. This extra information is designed right into the code system itself, taking advantage of its most likely application.

So far, discussion has been restricted to four-bit codes. This has been done keeping in mind the 8-bit data bus structures of microprocessors such as the 8008, 8080, or 6502. With more complicated codes, however, it is possible to add an extra bit to the data word to contain extra information about the data.

Parity. One of the more widely used complicated coding systems is called *parity checking*. Parity checking simply counts the number of 0's or 1's in a data word and assigns a value to an extra *parity bit*, depending on the result (Fig. 2). Thus a seven-bit code such as ASCII (American Standard Code for Information Interchange) might be transmitted in an eight-bit format, with one parity bit.

The *odd parity* system adds a 1 to a data word so that it always has an *odd* number of 1's in it. *Even* parity adds a 1 to cause an even number of 1's. Odd parity has a slight advantage, similar to excess-three, because every code word has at least one 1 or 0 in it, providing a verification of data-channel operation.

Note that with the parity system, if *two* errors occur in the same data word, parity check will not detect the error! But it will detect a three-bit error, or an error in any odd number of different bits.

DECIMAL	BINARY	PARITY
0	0000	1
1	0001	0
2	0010	0
3	0011	1
4	0100	0
5	0101	1
6	0110	1
7	0111	0
8	1000	0
9	1001	1
10	1010	1
11	1011	0
12	1100	1
13	1101	0
14	1110	0
15	1111	1

Fig. 2. Binary codes and odd-parity digits for decimal numbers 0 through 15.

BIT POSITION 01 02 03 04 05 06 07

DESIGNATION C_1 C_2 D_3 C_3 D_2 D_1 D_0

VALUE 0 1 1 0 0 1 1

DECIMAL 11 =

1011 BINARY

C_1 = mod 2 sum $(D_0+D_2+D_3)$
= (1+0+1) = 0

C_2 = mod 2 sum $(D_0+D_1+D_3)$
= (1+1+1) = 1

C_3 = mod 2 sum $(D_0+D_1+D_2)$
= (1+1+0) = 0

Fig. 3A. How Hamming-code check digits are generated.

	01	02	03	04	05	06	07
	C_1	C_2	D_3	C_3	D_2	D_1	D_0
RECEIVED VALUE	0	1	1	0	0	1	1

C_1' = mod 2 sum $(C_1 + D_0+D_2+D_3)$ = (0+1+0+1) = 0

C_2' = mod 2 sum $(C_2 + D_0+D_1+D_3)$ = (1+1+1+1) = 0 (C_3', C_2', C_1') = (0,0,0)

C_3' = mod 2 sum $(C_3 + D_0+D_1+D_2)$ = (0+1+1+0) = 0   NO ERROR

Fig. 3B. Check digits show that word was transmitted correctly.

	01	02	03	04	05	06	07
	C_1	C_2	D_3	C_3	D_2	D_1	D_0
RECEIVED VALUE	0	1	1	0	0	0	1

C_1' = mod 2 sum $(C_1+D_0+D_2+D_3)$ = (0+1+0+1) = 0

C_2' = mod 2 sum $(C_2+D_0+D_1+D_3)$ = (1+1+0+1) = 1 C_3', C_2', C_1' = (1,1,0)

C_3' = mod 2 sum $(C_3+D_0+D_1+D_2)$ = (0+1+0+0) = 1   ERROR IN BIT 6

Fig. 3C. The check digits show the error is in bit 6.

	01	02	03	04	05	06	07
	C_1	C_2	D_3	C_3	D_2	D_1	D_0
RECEIVED VALUE	0	0	1	0	0	1	1

C_1' = mod 2 sum $(C_1+D_0+D_2+D_3)$ = (0+1+0+1) = 0

C_2' = mod 2 sum $(C_2+D_0+D_1+D_3)$ = (0+1+1+1) = 1 (C_3', C_2', C_1') = (0,1,0)

C_3' = mod 2 sum $(C_3+D_0+D_1+D_2)$ = (0+1+1+0) = 0   ERROR IN BIT 2

Fig. 3D. The check digits show an error in bit 2, proof that even the error-protect digits are safe from error.

Multiple Errors. So far, the code structures and error-checking systems have provided enough redundancy to provide for some manner of single-error checking. But all fail pretty badly at detecting more than one error per datum.

Is single-error detection enough? Statistics (and the binomial theorem) say that for an error rate of one in 1000 transmitted bits, the odds of having two erroneous bits in a 5-bit word are one in 100,000. So, the single-error approximation seems a realistic, although simplistic, choice.

The amount of redundancy in an error-correcting code must be much higher than in a mere error-detecting code. Mathematicians, using such esoteric items as group theory, vector spaces and cyclic codes, have come up with a whole flock of codes that contain information about themselves, but most of them are best applicable when large bit-strings are processed.

Hamming Code. One of the simplest error-correcting codes is called the *Hamming code*, after its developer. The Hamming system for a four-bit datum, for example, generates three check bits, and the data must be transmitted in a particular manner (that is, the check and data bits interspersed in a particular manner) in order for the decoding and verification to correctly occur.

Suppose the decimal number 11 is to be transmitted. The binary representation is arranged in the indicated positions of the data word, in Fig. 3A and the check digits are generated by following the rules shown. The *modulo 2 sum* is the remainder (0 or 1) after adding a string of binary digits and disregarding any carry operations. The check digits go into the positions shown.

The resulting seven-bit word is now transmitted. The error-checking and results for a word transmitted with no error is shown in Fig. 3B.

Figure 3C shows the seven-bit word received with an error in data digit D1 in bit position 6. Note that, when the verification digits (C_3', C_2', C_1') are arranged as a three-bit binary number, they point right to the erroneous bit—the number 110 in binary is 6 decimal.

Figure 3D shows the seven-bit word received with an error in check digit C_2. The verification digits now form the binary number 010, bit position 2, where the error is!

Again, note that if two errors occur, it is impossible to completely reconstruct the data word with this given scheme. Multiple-error-correction codes do exist, however. ◇

CREATIVE RECORDING WITH 4-CHANNEL TAPE RECORDERS

How to achieve special effects such as echo, reverb, and balancing for stereo level and position.

BY LEONARD FELDMAN

ACCORDING to several audio dealers surveyed recently, one of the hottest items in all of high-fidelity componentry is the 4-channel, open-reel tape deck. Of course, sales of these multi-track machines don't even come close to those of better stereo cassette decks, but when you consider the fact that reasonably good 4-channel decks sell for around $600.00 and up, as opposed to Dolby-equipped cassette machines that can be had for as little as $200.00 or sometimes less, consumer interest in the open-reel format seems unusual.

Add to this the fact that very few recording companies offer even a meager selection of pre-recorded 4-channel programming on open-reel tapes and the sudden interest in these expensive machines becomes even more puzzling. Surely, owners of 4-channel, open-reel decks are not spending that kind of money simply to transcribe their newly acquired CD-4 or matrix 4-channel records onto tape, although of course that is one application for these quadraphonic recorders.

A clue to the most popular usage of these machines was uncovered by further questioning of dealers and by thumbing through some of the recent product offerings from manufacturers who normally concentrate on such conventional products as tuners, amplifiers, and receivers. They are now offering such "odd-ball" products as mixers and portable mixing consoles for consumer use. These include Shure, Teac, Sony, and others. Some of their mixers have six or more input channels and up to four output-channel facilities.

In addition, we found that microphone sales are better than ever at the consumer level, and we don't mean single microphone purchases to replace the original-equipment models supplied with cassette decks. We're talking about good dynamic and condenser microphones that sell from $50.00 and up. These are finding their way into home hi-fi systems in increasing numbers, as are separate Dolby noise-reduction systems, compress-expand systems, and others. From all this sales activity, we concluded that the big 4-channel decks aren't necessarily being used to record or play 4-channel programming at all! They are forming the basis of thousands of "home recording studios," often capable of turning out master tapes that rival some of the products made by professional studios.

"Sel-Sync" Makes the Difference. At least five makes of multi-track tape decks sold to consumers have an important built-in feature that enables users to employ some of the same techniques used in recording popular music. While just about any stereo or 4-channel deck is equipped with three tape heads (erase, record, and playback), the physical position of these heads in relation to tape travel is normally that shown in Fig. 1. The tape passes across the erase head first, where any previously recorded material is erased. Desired new program information is then recorded onto the tape as it passes in front of the record head and, a fraction of a second later, the newly recorded program can be "monitored" by the playback head and the playback preamplifier associated with that head.

This is a fine arrangement for making ordinary stereo or even 4-channel recordings, since it enables the operator to hear his recorded results (either via phones or through his speaker system) just a short time after the recording occurs. If he hears distortion, over-recording, or under-recording, he can correct control settings *almost* instantly. The delay is determined by the distance between the record and playback heads (in inches) divided by the tape speed (in inches-per-second). The faster the tape speed, the shorter the delay.

Suppose, however, that you wanted to record one tape track at a time, adding other tracks later. You might want to record the singing of a "one man quartet"—in which you or a talented friend provide all four harmonizing vocal parts

Pioneer's Model RT-2044 four-channel tape deck has "Synchromonitor" mechanism for sound-on-sound and sound-with-sound.

by making four separate single-track recordings which you would later mix together. With the head arrangement shown in Fig. 1, there is no way in which you could record the second, third, and fourth tracks in perfect synchronism with the first recorded track. Even listening with phones (so that the previously recorded track would not be picked up by your "live" mike), your newly added vocal part would be applied to track 2 just a little too late and, if you listened to a playback of track 2 and tried to add the track-3 program, it would be farther behind and so on.

This is where the principle of "Sel-Sync" comes in. It's an abbreviation for selective synchronization. Sel-Sync is the tradename used by Ampex, the well-known maker of professional tape equipment. It arises from the need to hear previously recorded tracks while simultaneously recording another signal in synchronization with them on the same piece of tape. It is the principle of Sel-Sync which is involved in many of the modern recording procedures in studios around the country.

Contrary to popular belief, most contemporary recordings are not recordings of "live" musical events at all. Using as many as 16, 24, or even more tape tracks, recording engineers assign single instruments or voices to one or more of these tracks. Very often, individual tracks may be recorded at different times—even in different studios. A master recording will contain all of the individually recorded tracks and these are then "mixed down" by the recording engineer, often with the aid of the producer and the artists themselves. It is during this mix-down process that individual tracks may be equalized ("sweetened" is the term used in the trade), augmented by echo or reverberation effects, rebalanced in terms of relative levels and positioned in the stereo or quadraphonic sound field. Sophisticated as these secondary steps may be, none of them would be possible were it not for Sel-Sync, which permitted the synchronization of all tracks in the first place.

How Sel-Sync Works: Although a record tape head is designed for optimum performance during its record function, there is really nothing to prevent one or more coils of the multi-track head from being connected to playback electronics and used as a playback head. If the record head were designed to do its best job in the recording function, chances are it would not exhibit the greatest frequency response or signal-to-noise characteristics when used as a playback head. However, if the sole purpose of its transition to a playback head is to enable recording artists to synchronize their efforts with previously recorded tracks, fidelity of reproduction heard through the monitoring phones is not that important.

The principle of Sel-Sync is shown in Fig. 2. A single track (say, track 1) is recorded by the first program source. Recorders equipped with Sel-Sync will have a switch (usually a two-position slide switch) associated with each recording track. In the diagram, the switch is set to its normal or "record" position, thereby connecting the track-1 record coil and gap to the record electronics. After the tape is rewound, the track-1 Sel-Sync switch is moved to its alternate position, connecting the track-1 coil to the playback preamplifier. All other record tracks remain connected to their respective record electronics, so that any one of them can now be recorded while listening to the results recorded onto track 1.

This procedure can be repeated until all four tracks have been individually recorded. Any one of the successively recorded programs can be used as the "monitoring" channel, except, of course, the track currently being used for the new track then being "laid down." If desired, two previously recorded tracks may be monitored simultaneously while the third is being added, so that the performer can hear both earlier recorded

The Otari MX-5050-QXH has "Sel/Rep" for recording two discrete but time-synchronized tracks.

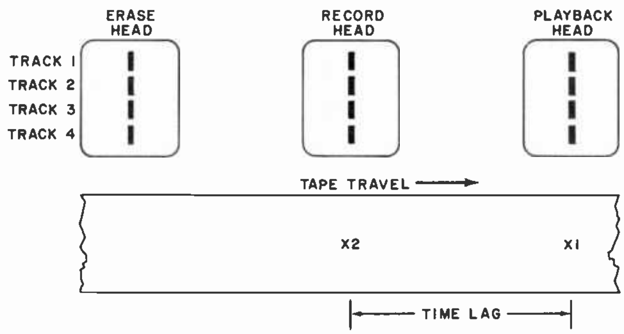


Fig. 1. If track 2 is recorded while listening to track 1's playback head, there is time lag between the programs.

tracks while adding his third track, and so forth. If there is acoustic isolation between the playback systems and the performing artist, monitoring can be done by the "home recording engineer" over speakers while the performer uses phones for the same purpose.

The possibilities are almost endless and, if you use your hi-fi component system for playback (assuming it's a 4-channel system for a quadraphonic mix attempt or a stereo system of a 2-channel mix-down) the tape output jacks of the receiver or amplifier can now be fed to a second deck (open-reel or cassette) onto which your properly mixed-down version of the recording can be recorded. It is at this point that mixers become most useful, since each of the four "raw" tracks can now be treated as a signal source into the mixer, which, depending on its flexibility and control features, becomes your home-recording console. Even without this addition, you'll find that 4-channel decks equipped with Sel-Sync also have individual level controls for each channel or track which enable you to balance relative levels before the final "master" mix-down or dubbing is made.

At least five manufacturers we know of have 4-channel open-reel decks available that include the selective synchronization feature. Teac offers the feature, which it calls "Simul-Sync," on its Models 3340S and 2340R machines. The chief difference between the two is that the lower priced 2340R unit accepts 7" reels and operates at 3¾ and 7½-ips speeds, while the costlier version accepts 10" reels and operates at 7½ and 15-ips tape speeds. In Akai's GX-630SS 4-channel deck, the feature is called "Quadra-Sync." This machine operates at two speeds and accepts large-size tape reels. Dokorder's synchronizing function is called "Multi-Sync," and is found on their 3¾-7½-ips, 7"-reel Model 7140 and their 7½-15-ips, 10½"-reel Model 1140, both with electronic echo, sound-on-sound, and sound-with-sound recording. Otari's MX-5050-QXH calls its version "SEL/REP," while Pioneer calls it "Synchomonitor." All of these machines have individual mike and line mixing controls for each channel, affording a great measure of flexibility even if a separate multi-channel mixer is not part of your home-recording set-up.

We visited a home-recording set-up which included a Teac 3340 and an Akai. With two decks, this enthusiast is able to do Sel-Sync recording of his masters and then transcribe the results, properly mixed and re-blended, to the second deck. The photos show close-ups of the Simul-Sync switches on the Teac machine and the equivalent push-button switches (one for each track) on the Akai unit.

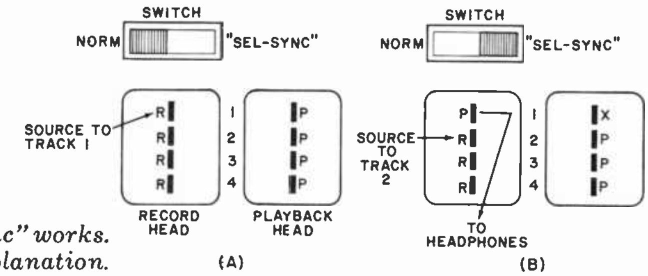
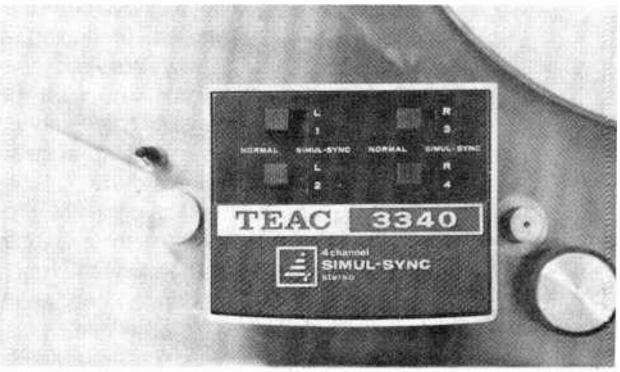


Fig. 2. How "Sel-Sync" works. See text for explanation.

Noise Reduction: A pair of Dolby noise-reduction units is used with these 4-channel decks. Why add Dolby to such fine decks, each of which can easily produce a signal-to-noise ratio of 60 dB or more when used with quality tape? Simply because if you're going to do any dubbing (successive copying of tape-to-tape), each dubbing process will add a few dB of noise to the finished product, so you want to start out with every last



Closeup of "Simul-Sync" track switches on Teac 3340.

Akai "Quadra-Sync" track-selector buttons.

dB of signal-to-noise you can get. In this particular "home studio," the Dolby units are hooked up to the Teac deck, which serves as the master recorder. Dolby decoding is used during playback as the raw tracks are re-recorded onto the Akai machine, thereby affording more "headroom" to the finished mixed-down master tape.

Often the owner of this set-up has to transcribe his master tapes onto a cassette. To achieve best signal-to-noise ratio here, he uses a dbx Series 122 2-channel noise-reduction system. Working on a different principle from Dolby, this unit compresses the recorded material by 2 to 1 during recording and then, when the proper buttons are pushed, re-expands the program during playback by the same factor. The combined action increases the dynamic range by a wide margin while reducing noise and is especially useful with cassettes where over-recording or tape saturation is much more of a problem than with open-reel units.

Sony Model MX-510, a 5-input, 2-output mixer unit.

Other Applications. You can simulate four-channel sound when recording two-channel (some old stereo tapes, perhaps) by returning the monitor output to the record head. In effect, you use the time delay between the playback and record heads to obtain an echo effect.

A tape technique that's mind-boggling is sound that circles the room. This can be accomplished with a "pan pot" to gradually move the sound from one channel to another. (Two Teac AX-10 stereo echo units make it easy to achieve such results, by the way. They enable a user to vary the degree of echo and incorporate impedance-matching networks.)

Having four independent channels at hand, all in perfect synchronization, offers new recording opportunities. From the standpoint of quality, it beats sound-on-sound since the former is a second-generation recording (recorded on the originally recorded track) with attendant fidelity losses, while a Sel-Sync deck can provide first-generation tapes. So now it's easy to make four independent recordings (actually you can make seven first-generation recordings by using mix-down techniques). What can you do with at least four tracks? For starters, one track can be used for voice, a second for background music, a third for special effects, a fourth for voice-over or another voice, perhaps singing or whatever else you choose. You're only limited by your imagination.

Isn't a Studio Cheaper? The equipment described here—which does not include any microphones or even the cassette machine used—adds up to nearly $4000.00. The question naturally arises whether a serious recordist (or musical group, or singer, or instrumentalist) wouldn't be better off renting time at a professional recording studio. Well, perhaps he would, but these days, studio time sells for upwards of $100.00 an hour if you're talking about a top studio—and the hours have a way of ticking by as you wait for studio set-up, do several unsuccessful takes, wait for an acceptable mix-down, and the like. With so many aspiring groups around, it's not surprising that they opt for a home set-up not unlike the one described, for then they can afford to do as many "takes" as are necessary for a good "auditioning tape."

Dokorder's 7140 2/4 channel deck with "Multi-Sync."

More than one successful recording group has used this approach to "breaking in" to the entertainment field, and stories of these successes have led other aspirants to make the investment in this kind of equipment. By way of comparison, even the relatively moderately priced mixing console manufactured by Tascam (the professional division of Teac), and considered to be the logical "bridge" between consumer equipment and truly professional studio console equipment, costs nearly $2000.00 in its most elementary form. It can run several thousands more when equipped to maximum capacity, features, and number of input and output channels—and that's without considering even one tape deck or transport which would have to be used with the board.

Surprisingly, not everyone who owns the kind of equipment we have been discussing aspires toward producing a "golden record." Many are just seasoned audio enthusiasts who want the kind of recording flexibility and professionalism afforded by this kind of gear. Perhaps all they will record are "off-the-line" tapings of their favorite FM programs or dubbings from their favorite discs. But with imagination and good equipment, they can bring to bear an involvement and creativity that makes it all worthwhile and changes high fidelity from a passive hobby into a very active and exciting pastime. ◇

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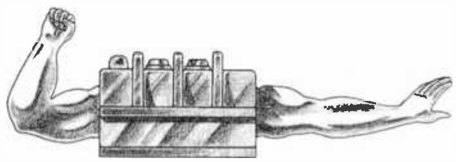

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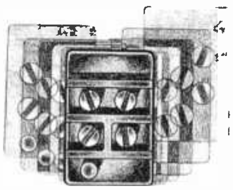

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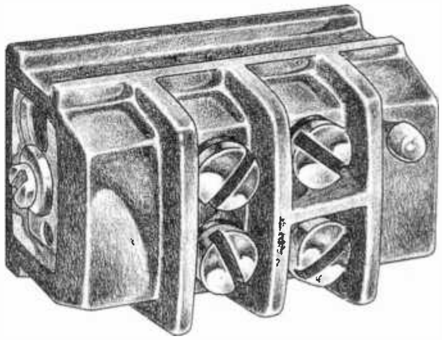

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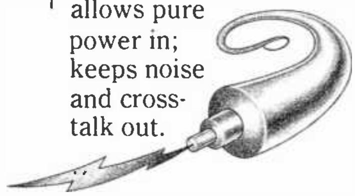

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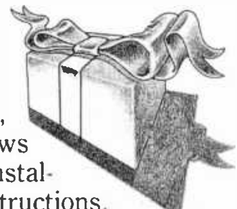

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CHASING FOREIGN DX ON THE BROADCAST BAND

Modest equipment and patience can be very rewarding on the BCB— especially with low sunspot activity.

BY HARRY L. HELMS

PREDICTIONS point to a low level of sunspot activity in 1977. For SWL's and other users of the higher frequency shortwave bands, such news isn't very welcome. But if you enjoy searching for DX on the standard broadcast band, the lower level of solar activity means exciting opportunities for longhaul reception that is impossible in years of high sunspot activity.

Many SWL's got their start by DX'ing on the standard broadcast band (BCB) and then moved on to other bands. But if you are interested in tough DX—stations that are rarely heard and require skill and patience to tune in—the broadcast band can give you a challenge unsurpassed by any other range of frequencies.

You don't need a roomful of gear or a huge bankroll to hear some exciting DX. It's true that some BCB DX'ers have developed specialized loop antennas and such techniques as differential sideband detection to aid DX reception, while others have done outstanding research into radio-wave propagation on the BCB. But several DX'ers in the Eastern United States have reported reception from Europe and Latin America on portable receivers costing less than $30. An excellent BCB DX listening setup can be purchased very inexpensively on the used-equipment market.

More important than your equipment is whether you have the attributes required of a successful DX'er. You need patience to wait for the DX openings, skill to exploit the openings, and a little bit of luck as well.

What you can hear depends greatly upon your location. Listeners on the East Coast have opportunities to hear European, African, Middle Eastern, some Asian, and a few Pacific area stations. Listeners on the West Coast have chances for Asia, Australia, New Zealand, the Pacific Islands, and Alaska. Both coasts can hear Latin America and the Caribbean, although most agree that East Coast listeners have the edge over the West Coast in hearing the latter. Listeners in the Midwest have shots at everything from Australia and Asia to Africa and the Middle East, although reception from the various areas is often quite difficult. Several listeners on the East Coast have heard over 100 countries (the champ, Gordon Nelson of Massachusetts, has heard over 130 countries) while expert West Coast listeners have country totals in the sixties.

QSL from Bayerischer Rundfunk, 1586 kHz, is very colorful.

It must be emphasized that, under proper conditions, all areas of the United States have a chance at any area from the west coast of Africa to Australia and east Asia. For example, 50-kW Australian BCB stations have made it to the Northeastern United States, while the 10-kW transmitter of Sierra Leone, located on the east coast of Africa, has been heard in California. Even Radio Peking's 1525-kHz station has been heard by several listeners on the East Coast. And now is a prime time to hear such DX, while the sunspot count is low.

Propagation. Years of low solar activity are conducive to long-haul BCB DX. The low sunspot numbers that wreck the higher shortwave frequencies reduce signal absorption on BCB frequencies. Thus, more signal reaches the listener and less gets gobbled up by the ionosphere.

Most BCB DX'ers confine their listening to the autumn and winter months, typically from early September to early April. Summer months are characterized by high noise levels and low signal levels that are due to increased ionospheric absorption produced by the longer days. Some advanced listeners have discovered that summer is a prime listening time for certain African stations that are covered up by European stations in winter. We will not concern ourselves with such advanced and difficult DX here.

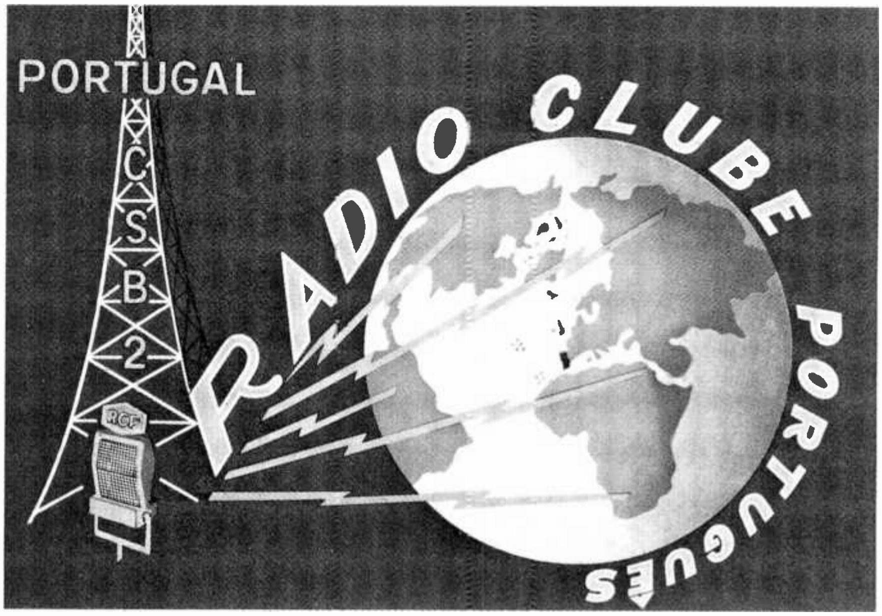
For the past few years, October has yielded some of the best DX heard during the entire DX season. The months of December and January, favored by those who look for domestic DX on the BCB, often produce mediocre DX conditions for foreign DX. The reasons behind this so-called "Midwinter Anomaly" have been researched by the National Radio Club. The NRC has a series of reprints available on this and other propagation topics.

Standard time and frequency station WWV can provide BCB DX'ers with valuable clues as to probable reception conditions for BCB DX. This is because it transmits the "A index," a measurement of the influx of electrically charged particles into the upper atmosphere. A-index values of 20 or more are usually sufficient to disrupt long-haul DX along high-latitude paths, such as East Coast to Europe or West Coast to Japan. When A-index values go over 40, severely disturbed conditions result that blank out many North American stations and allow Latin American stations to the south to dominate many channels. Such conditions are often termed "auroral" by BCB DX'ers because auroral displays often accompany such conditions in the winter.

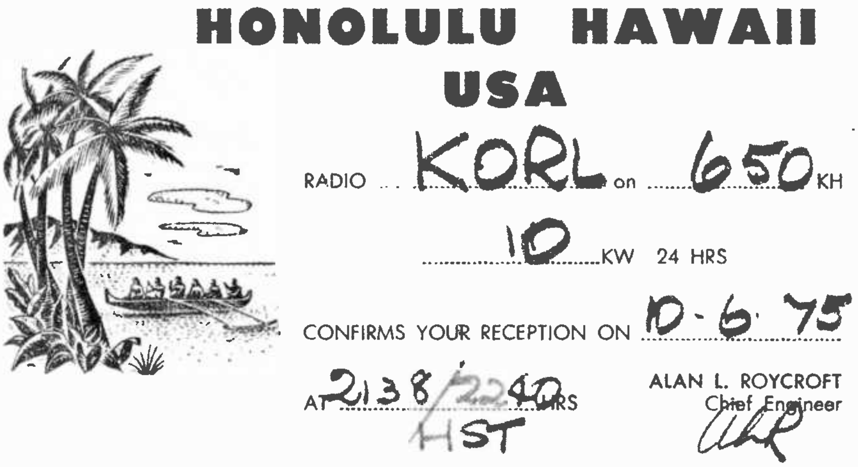
The A-index values are transmitted by WWV at 18 minutes after the hour. Many BCB DX'ers make it a habit to tune in daily to these announcements during the DX season and keep a record of the daily values. When two or more consecutive days of low values (10 or less) are noted, odds are good that long-haul DX will be possible. When values are high, conditions for reception of Latin American stations will usually be excellent. There are exceptions to these rules, however, and the seasoned DX'er knows there is no real substitute for listening for those elusive openings.

Time to Listen. Domestic BCB stations, even those that run 24-hour operations, usually sign off on Monday mornings after midnight for maintenance and tests. Thus, interference from American and Canadian broadcasters tends to be at a minimum on a Monday morning, starting at midnight Eastern local time. Unfortunately, a good opening to Europe or South America doesn't always fall on a Monday morning. So, those chasing foreign BCB DX often have to buck some heavy interference. Nevertheless, most BCB DX'ers try to listen every Monday morning, even during summer, since many stations in Latin America otherwise covered by domestic stations can be heard.

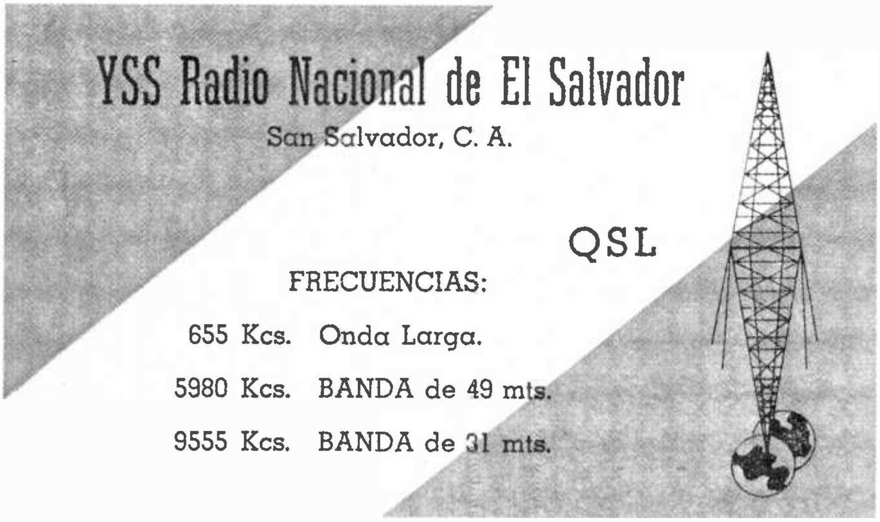
If you are tuning for stations in Latin America or the Caribbean, you can tune any time from shortly after your local



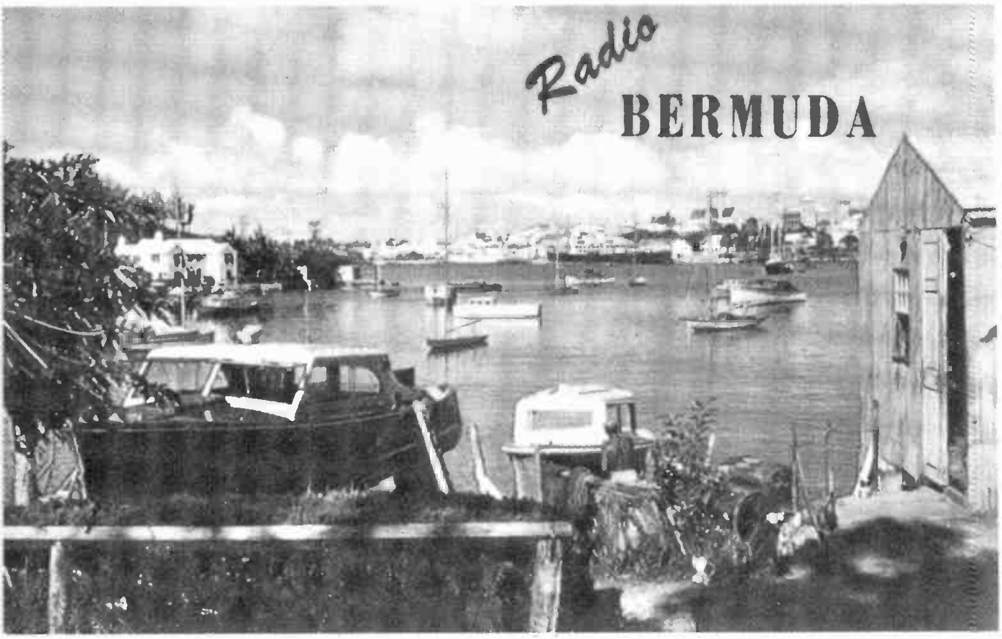
CSB2 Radio Clube Portugues, 1034 kHz, in Portugal, sends out this QSL.



Radio KORL, 650 kHz, Honolulu, Hawaii, confirms reception with date and hour.



YSS Radio Nacional de El Salvador, San Salvador, sent this QSL for 655-kHz reception.



This scenic QSL was received from Radio Bermuda, broadcasting on 1235 kHz.

sunset until just prior to your local sunrise. (Note, however, that many Caribbean stations sign off before 0500 GMT.) Eastern listeners tuning for Europe or Africa can try before 0000 GMT because that is when most Europeans sign off. (Although there are some all-night operations.) A prime tuning time for these "Trans-Atlantic" stations is from 0500 to 0600 GMT, when many of these stations can be heard signing on. Reception of these stations lasts until approximately 0700 GMT, when sunrise in Europe and Africa ends chances for reception.

Tuning for Oceania and Asia tends to be a late-night affair for many DX'ers. Hawaii and other Pacific-area stations typically become audible from 0700 GMT onward during the autumn/winter DX season. Australia, Japan, China, and similar Asian targets often fade in around 0900 GMT and remain possible until roughly 1300 GMT.

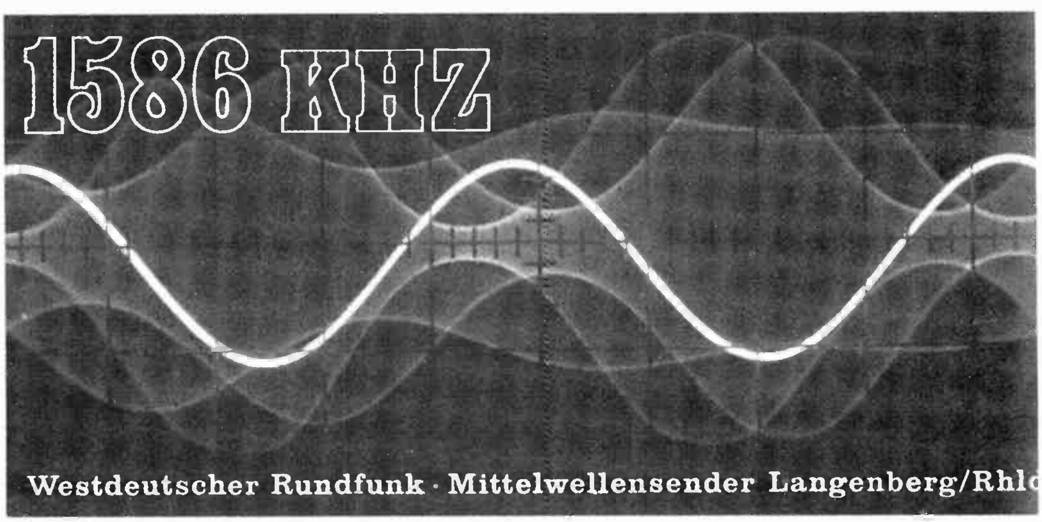
Keep in mind that the bulk of the signal path of a BCB station's signal must be in darkness for long-distance reception to occur. Thus, reception of European stations on the West Coast just prior to the 0000 GMT sign-off time for Europe just is not possible—nor can an East Coast listener hear Asian stations at 1200 GMT.

Selecting Targets. As a general rule, the listener just starting to chase foreign BCB DX should try his hand at logging Latin America. Year-round, more openings occur for Latin America than any other area. The signal levels are better than other foreign DX, and less sophisticated equipment is required than for Trans-Atlantic or Trans-Pacific reception. Finally, most DX'ers find it easier to try to identify a Spanish-speaking station rather than one in Japanese or Polynesian.

Many stations from Latin America are evening regulars in the United States. Listeners in the East can often hear Cuba on 590, 600, 630, 640, and 690 kHz with Spanish programming. Listeners in the Central and Western states often hear Mexican stations, such as XEWA (540 kHz) and XEW (900 kHz) with Spanish-language programming. Some Mexican stations, however, program in English and run high power. West Coast listeners may already be quite familiar with XETRA-690 and XEPRS-1090, while Midwestern listeners may regularly tune in XEG-1050 and XERF-1570. These stations, although located in Mexico, program for an American listening audience.

Stations in Central America are the most commonly heard Latin sources after Mexico and Cuba. Colombia and Venezuela are the most commonly heard countries from South America. Many stations in the latter two nations operate all-night on Monday mornings and are widely heard with the lessened domestic interference.

In the United States and Canada, all BCB stations operate on an even 10-kHz channel plan, starting with 540, 550, 560 and so on, up to 1600 kHz. Such spacing is rigidly adhered to in the U.S. and Canada. Many stations in Latin America and the Caribbean operate between the evenly spaced domestic channels and are known as "split-channel" stations. Some of these splits are easily heard during the evening, such as Belize-834, Haiti-1035, and St.



Westdeutscher Rundfunk, 1586 kHz, uses this more technical design.

Kitts-1265. Eastern listeners frequently report Surinam-725 and Cayman Is.-1555 during the evening. A receiver with good selectivity helps in receiving "splits," although the potent signals of the more common splits make reception not too difficult even on simple receivers.

As mentioned earlier, when the WWV A-index exceeds 40, check for exceptional conditions to Latin America. From his location in the Southeast, this author finds that with such high A-index readings, many Northern clear-channel stations are completely wiped out, leaving many Latin American outlets dominant, just as if one were listening somewhere in Latin America!

Houses of Parliament and the Thames dominate the QSL from England's BBC on 1295 kHz.

Trans-Atlantic Stations. Unlike the 10-kHz channel spacing in North America, broadcasters in Europe and North Africa operate on channels spaced 9-kHz apart, with the BCB extending from 529 to 1602 kHz. This means that many European and African stations operate on split channels. Power levels of the European and African stations are much higher than the average domestic station in North America. For example, the maximum power permitted an American or Canadian BCB station is only 50 kW, whereas powers of several hundreds of kilowatts are quite common in Europe.

QSL received from Swiss station on 1562 kHz.

Such power, coupled with split frequencies, means that quite a few stations can cross the Atlantic with ease. The one drawback for the BCB DX'er is the rather weak modulation used by Trans-Atlantic stations. This means that the carriers from such stations will often be quite strong, but readable audio will be difficult to obtain.

Listeners located in the East generally agree that signals above 1500 kHz are heard much more often than signals lower in frequency. A good "beacon" for Trans-Atlantic reception is West Germany's Westdeutscher Rundfunk outlet on 1586 kHz. This station uses a walloping 800 kW and operates all night. It's heard at the author's southeastern location even when no other European BCB stations are being heard. If WDR isn't being heard, no other Trans-Atlantic station is likely to be heard. You can try for WDR after your local sunset until approximately 0700 GMT. Programming is generally pop music and German announcements.

Listeners located in the central and western parts of the United States often find reception of European and African stations best in the middle and lower ranges of the BCB. A good beacon for the lower frequencies is the 845-kHz outlet of Rome, which is an all-night operation like WDR. Look for news bulletins in various languages on the hour and half-hour with uninterrupted music between newscasts. This, too, should be possible from your local sunset until 0700 GMT. Quite often this station is louder on the East Coast than any domestic station on 840 and 850 kHz.

Signals from the Middle East follow the same signal path as European and African stations and listening techniques are similar. An exciting new catch for many BCB DX'ers has been Turkey's new outlet on 1016 kHz. This 1200-kW monster has enabled many listeners to hear a new country on the BCB. Check our list for other good possibilities from Trans-Atlantic reception.

Trans-Pacific Reception. West Coast listeners have the edge here, of course, although some signals manage to make it to the East. Transmitter powers here are, on the average, quite a bit lower than for the European stations and, therefore, provide a severe test for the Eastern listener. Modulation levels are good, though, and usually some audio will make it whenever the carrier can be detected. Channel spacing is a hodge-podge, with some stations using 10 kHz, 9 kHz, or their own unique system of spacing.

Alaska, believe it or not, is considered to be Trans-Pacific due to the way the signal is propagated. This state is almost impossible to receive now from the East Coast, but listeners in the Midwest and West have several targets to shoot for, with KYAK-650, KFAR-660 and KFQD-750 being most likely. The auroral shield absorbs a tremendous portion of the radio energy of Alaskan stations,

USEFUL ADDRESSES

National Radio Club, membership center, Box 118, Poquonock, CN 06064. Established in 1933, publishes *DX News* 30 times a year, weekly during the autumn/winter DX season. Sample *DX News* and membership information can be obtained for 50¢. Publishes an extensive set of technical manuals and reprints from *DX News,* with a list available by sending self-addressed stamp envelope. Also publishes a detailed log of domestic stations and antenna patterns.

International Radio Clubs of America, Box 21462, Seattle, WA 98111. Established 1964, publishes *DX Monitor* 34 times a year, weekly during the DX season. Sample bulletin and membership details can be obtained for 50¢. Publishes the *IRCA Foreign Logs*, which are compilations of stations reported as heard by IRCA members to the foreign DX column in *DX Monitor.*

Medium Wave Circle, 7 The Avenue, York, YO3 6AS, England. Publishes *Medium Wave News,* detailing DX reception in the British Isles and Europe. Send three International Reply Coupons for information.

HAWAIIAN HOPEFULS

kHz

650—**KORL,** Honolulu, Monday mornings after 0700 GMT with WSM off, may be WRM from HJJX in Bogota, Colombia along East Coast. Rock-and-roll format.

690—**KKUA,** Honolulu, Monday mornings from 0700 GMT until local dawn, very difficult in East, QRM from XETRA in West, rock and roll format.

830—**KIKI,** Honolulu, after 0700 GMT until local dawn but WCCO makes reception in East very difficult, rock and roll format.

1040—**KHVH,** Honolulu, Sunday mornings after WHO sign off at 0600 GMT until local sunrise, pop and middle-of-the-road format.

1350—**KIVM,** Lihue, Monday mornings from 0700 GMT to local sunrise, crowded channel but has been heard in New Jersey in recent years, rock and roll format.

TRANS-ATLANTIC ATTRACTIONS

kHz

665—**Portugal,** Lisbon, an all-night operation possible from local sunset until approximately 0700 GMT. Pop instrumentals and vocals usually featured.

737—**Spain,** Barcelona, Radio Nacional de Espana, another all-night operation with varied programming.

764—**Senegal,** Dakar is often the easiest African at 0600 GMT sign-on with chants.

845—**Italy,** Rome, "Nocturne from Italy" features news bulletins on hour and half-hour and pop music, usually best station on the lower BCB frequencies.

854—**Spain,** Murcia, another all-night operation; be careful not to confuse with Peru.

1016—**West Germany,** Sudwestfunk, Mainz, all evening with German pops and announcements.

1016—**Turkey,** Istanbul, sign on 0200 GMT, Turkish music and female announcer until fade out around 0600 GMT. Signal often mixes with that of the West German

1205—**France,** Bordeaux, after 0500 GMT with ethnic language programming, French after 0600 GMT.

1214—**England,** BBC, common wave channel with domestic service, pops and rock, usually 0600–0700 GMT.

1394—**Albania,** Radio Tirana, Tirana, foreign service, various languages, often well after 0530 GMT.

1403—**Guinea,** Conakry, from local sunset to 0700 in French and African languages.

1466—**Monaco,** Trans World Radio, Monte Carlo, sign-on 0445 GMT with religious programming.

1475—**Austria,** Vienna home service after 0500 GMT in German, pop music.

1538—**West Germany,** Deutschlandfunk, Mainflingen, after 0500 GMT in German, pop and light music.

1554—**France,** TeleDiffusion de France, Nice, after 0500 GMT with French talk and music. Usually second best high-frequency bet.

1562—**Switzerland,** SBC home service, Samen, sign-on 0500 GMT with German talk and music.

1586—**Germany,** Westdeutscher Rundfunk, GMT Langenberg, from local sunset to approximately 0700 GMT, German music and talk, by far the easiest Trans-Atlantic station for most DX'ers.

LATIN AMERICAN AND CARIBBEAN POSSIBILITIES

kHz

540—**Mexico,** San Luis Potosi, XEWA, Spanish programming evenings.

550—**Cuba,** Pinar del Rio, Radio Rebelde, Spanish programs evenings, carries "La Voz de Cuba" program all night.

595—**Dominica,** Radio Dominica, Roseau, English until 0230 GMT sign-off with U.S. pops and standards, difficult from the West Coast.

600—**Cuba,** Holguin, Radio Rebelde, same time and programs as Cuba-550.

640—**Cuba,** Havana, Radio Liberacion, Spanish programming evenings and carries "La Voz de Cuba" all night.

655—**El Salvador,** San Salvador, YSS, Radio Nacional de El Salvador, Spanish programs with much classical music until 0445 GMT sign-off.

675—**Costa Rica,** Radio Sonora, San Jose, with usual Latin American programming, evenings and nights until past 0500 GMT.

725—**Surinam,** Stichting Radio Omroep Surinam, Paramaribo, evenings in English, Dutch, Hindi and other languages until 0330 GMT sign-off.

800—**Netherlands Antilles,** Trans World Radio, Bonaire, religious programs in various languages in early evenings.

825—**Costa Rica,** Radio Titania, San Jose, all night with lively Latin American programming.

834—**Belize,** Radio Belize, Bellze City. Former British Honduras, now independent nation, mostly English until 0500 GMT sign-off, perhaps easiest split channel.

900—**Mexico,** Mexico City, XEW, same times and programming as XEWA-540.

1035—**Haiti,** 4VEH, Cap Haitien, religious programming, mostly English, until 0030 GMT sign-off. Second best split behind Belize-834.

1055—**Colombia,** La Voz del Centro, Espinal, all night with lively Spanish programming and commercials.

1200—**Venezuela,** Radio Tiempo, Caracas, YVOZ, Spanish programming with many identifications, time checks, and commercials, Monday mornings after WOAI sign-off at 0600 GMT.

1265—**St. Kitts,** Radio Paradise, St. Kitts, with English religious programming evenings until 0300 GMT sign-off.

1555—**Cayman Is.,** Radio Cayman, English program evenings until 0330 GMT.

1570—**Mexico,** XERF, Ciudad Acuna, English programming evenings.

TRANS-PACIFIC POSSIBILITIES

kHz

655—**North Korea,** Pyongyang, Korean home service programs from approximately 1000–1300 GMT, perhaps easiest Trans-Pacific station; has been heard on East Coast.

750—**Japan,** Sapporo, JOIB, Japanese programming but sometimes has English lessons, 0930 GMT until KXL sign-on.

770—**Japan,** Akita, JOUB, Japanese programming but often has English lessons like Sapporo-750, 0930 to approximately 1300 GMT, KOB often presents severe problems.

830—**Japan,** Osaka, JOBB, same programming as 750 and 770 kHz with some English lessons, 1000 to approximately 1300 GMT, WCCO main source of interference.

835—**China,** Nanchang, Chinese domestic service with many shrill voices, and much martial music from 1000 to 1400 GMT.

844—**Gilbert Islands,** Tarawa, English and various Polynesian languages from 0700 to sign off around 1000 GMT. Was heard in New York City area in autumn 1975.

877—**North Korea,** Wonsan, Korean home service, same programming and times as 655 kHz, frequency often drifts.

1040—**China,** Shanghai, Chinese and Japanese programming, Sunday mornings with WHO off 1000–1300 GMT.

1525—**China,** Urumchi, Russian foreign service 2300–0000 GMT. Has been widely heard on East Coast but rarely on West Coast, due to darkness path from Urumchi to the East Coast over the North Pole.

1550—**Australia,** Queensland, 4QD, cultural programs of classical music, discussions, and news from 0900–1100 GMT. Main interference is from domestic stations, has been heard on East Coast.

ATTEMPTABLE ALASKANS

kHz

560—**KYAK,** Anchorage, Monday mornings after 0700 GMT with WSM off, country and western music format.

660—**KFAR,** Fairbanks, Monday mornings with WNBC off until 0900 GMT sign-off, rock and roll format.

750—**KFQD,** Anchorage, Monday mornings with WSB and KXL off until 1000 GMT sign-off, pop and middle-of-the-road music format.

thus making this state a noteworthy DX catch even in the Pacific Northwest.

Hawaii is somewhat easier than Alaska to receive. The most commonly heard station is KORL-650, usually noted on Monday mornings after the sign-off of WSM in Nashville. Reception is best after 0700 GMT. The station uses a rock-music format. It is more difficult to receive in the East now that Emisoras Monserrate in Colombia operates all night on 650 kHz. Other Hawaiian possibilities are KKUA-690, KIKI-830, and KIVM-1350. Try for these after 0700 GMT. All have been heard on the East Coast, although interference from all-night stations often makes reception quite difficult.

Another catch reported on the East Coast is Tarawa (844 kHz), located in the Gilbert Islands southwest of Hawaii. Their 10-kW signal is most often heard after 0800 GMT, with native music and language for quite exotic listening.

Mainland China and Japan are the easiest Asian stations to receive from the West Coast, although reception is extremely rare farther east. Japanese stations most easily heard include those on 750, 770, and 830 kHz. China has easily heard powerhouses on 835 and 1040 kHz. North Korea is often heard on 655, 725, and 877 kHz, but the last frequency drifts a few kilohertz.

Australian stations operate on the 10-kHz spacing used by stateside stations. This provides problems for DX'ers because by the time many Australian stations start to fade in, many domestic stations are beginning to sign on. The most widely heard Australian station is 4QD, Emerald. Try for it on 1550 kHz after 0830 GMT. It was heard in Florida as recently as 1970 but is extremely difficult farther northeast. Listeners in the Midwest and along the West Coast should have more luck.

Listeners trying for Trans-Pacific stations should remember that signals traveling such long distances are subject to rather deep fades, even though they may be quite loud on peaks. Thus, spend a few minutes on the frequency of the station you wish to hear before tuning away.

Receivers and Antennas. Many BCB DX'ers use equipment that's several years old. One reason is that many manufacturers of receivers today don't make quality receivers that cover the BCB. Secondly, many receivers are designed for SSB reception, but BCB DX is concerned with the reception of AM signals.

Selectivity is a prime requirement of a BCB DX receiver. Older models that have a Q-multiplier, crystal filter, or mechanical filters are highly popular with BCB DX'ers. Receivers are often highly modified according to plans available from the two BCB DX clubs. Favorite receivers are often those used when amateurs used a great deal of AM phone. Examples of popular receivers available on the used equipment market are the Hammarlund Models HQ150 and HQ180. The Drake Model SPR-4 is a current receiver that has gained popularity among BCB DX'ers. Military surplus receivers, such as the Models SP600, R388 and R390, are also highly prized by BCB DX'ers.

The old reliable long-wire antenna is still used by many BCB DX'ers, but every serious listener now uses a loop antenna of some sort. A loop is a bidirectional antenna that responds best to signals along its plane and rejects stations at right angles to that plane. Thus, a loop offers a way to minimize interference. Thanks to preamplifiers, a loop can offer substantial gain over a long-wire antenna. Older loop models were of air-core design, often 3′ (0.91 M) or longer per side. Modern ferrite-core loops are quite compact and offer high performance.

A variation of the long-wire is the Beverage, which should appeal to listeners who live in rural areas with a great deal of space. A Beverage is a straight wire measuring more than 1000′ (304.8 M) in length, affording great gain and directivity. Plans for these are available from the two BCB DX clubs.

Verifications. Program detail for a BCB report should be greater than for a shortwave report. Commercials are the best material, along with announcers' names, slogans, jingles, program names, with song titles often being of little value (although they can seldom hurt). Do *not* use SINPO or other reporting codes; use only plain language. Use the native language and time of the station you heard, and always include return postage except when reporting to government-operated stations such as the BBC or an East European station.

Now is the Time. BCB DX opportunities must be taken advantage of when present—and the current low sunspot count provides an opportunity that won't be present again for some time. In addition, increasing numbers of all-night stations and the chance of greater power for American BCB outlets may severely curtail BCB DX in the future. ◇

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BUILD A STATE-OF-THE-ART BATTERY CHARGE MONITOR

Prevents early failure of Ni-Cd batteries by determining proper time to recharge.

BY W. J. PRUDHOMME

THE PRIMARY cause of early cell failure in nickel-cadmium batteries is internal shorting that results from allowing the battery to become too deeply discharged in service. Therefore, any electronic device that uses Ni-Cd cells should contain a low-battery indicator that trips and warns you to recharge long before the battery's "critical" voltage is reached. Though there are a number of different types of charge monitors you can incorporate into your battery-powered equipment, the lambda-diode monitor described here is more advanced than other monitors in use.

Most low-battery indicators use a transistor to switch on the drive current for a LED or meter movement. The disadvantage here is that the monitor circuit places a constant drain on the battery, even when the LED is extinguished. In low-power applications, this drain can drastically reduce the available operating time of the battery. The ideal solution is to use a circuit that draws no current from the battery as long as the supply voltage is greater than the critical potential of the battery. This is what the lambda-diode monitor does. In addition, the trip potential is adjustable over an 8-to-20-volt range, and cost is low.

Technical Details. The output potential of most batteries varies in relation to the state of charge. This relation is different for each type of battery. Lead-acid batteries, for example, exhibit an almost linear dropoff in output voltage as the cells become discharged. The same is generally true for dry cells. For Ni-Cd batteries, however, the dropoff is not quite linear.

A fully charged Ni-Cd cell has an output potential of typically 1.25 volts. The cell maintains an almost constant output potential until it is almost completely discharged, at which point, the potential drops rapidly to about 1.0 to 1.1 volts, or 1.05 volts average. A precise voltage monitor set to trip at this "critical" voltage level (or at a multiple of this potential if more than one cell is in series) can be very useful in determining the charge level of the battery.

An eight-cell Ni-Cd battery pack, for example, would have a fully charged output potential of 10.0 volts. When nearly completely discharged, the battery would have an output of 8.4 volts. If the lambda-diode monitor circuit shown in Fig. 1 were set to trip at 8.4 volts, we have a useful state-of-charge monitor for a Ni-Cd battery system.

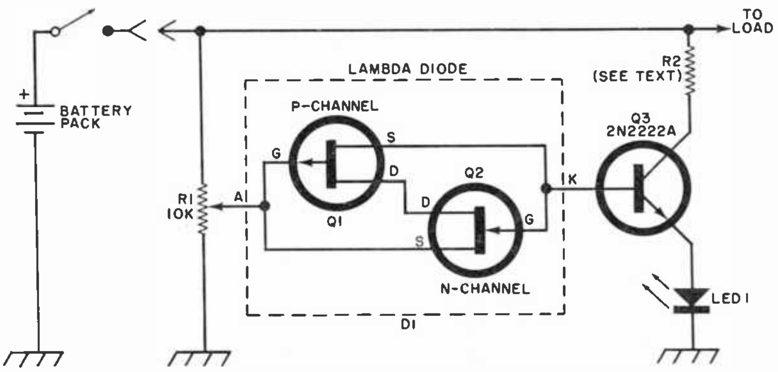


Fig. 1. Battery charger uses a lambda diode made of 2 FET's.

PARTS LIST

LED1—Any discrete light-emitting diode
Q1—P-channel junction field-effect transistor (2N4360 or similar)
Q2—N-channel junction field-effect transistor (2N3819 or similar)
Q3—Silicon switching transistor (2N2222A or similar)
R1—10,000-ohm, 1/5-watt miniature pc potentiometer
R2—Current-limiting resistor (see text for details on how to calculate value; typically about 150 ohms, ½-watt)
Misc.—Printed circuit board or perforated board and solder clips; relay (substitutes for LED1; see text); hookup wire; solder; etc.

The two-terminal, negative-resistance lambda diode shown inside the dashed box in Fig. 1 consists of one each n- and p-channel FET's. (There is no "lambda" diode available commercially.) Note that in this configuration there are only two terminals, which can be labelled "anode" (A) and "cathode" (K).

If the lambda diode is biased into cutoff, transistor *Q3* is also cut off and *LED1* is off. As battery voltage drops, a point is reached where the lambda diode abruptly conducts. This biases *Q3* into conduction and turns on *LED1* to indicate a low-battery condition. (The operating characteristic of the lambda diode is shown in Fig. 2.)

The potential at which the lambda diode conducts can be adjusted by potentiometer *R1*. Resistor *R2* is a current limiter for *LED1*. Its value is determined by Ohm's Law (*R2* = E/I, where *R2* is in ohms, E is the potential of the battery at the point *LED1* turns on, and I is the operating current of the LED used.

Construction Details. The lambda-diode battery-charge monitor is small enough to be built into the equipment in which a Ni-Cd battery pack is used for power. Alternatively, it can be assembled as an external low-battery indicator accessory and housed in a small utility box. In either case, printed-circuit (Fig. 3) or perforated board construction can be used.

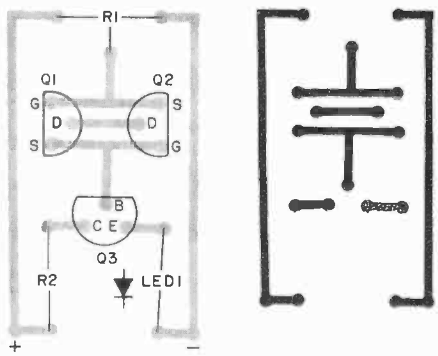


Fig. 3. Etching and drilling guide (right) with component layout (left) can be used or a perforated board will do.

The choice of JFET's for making up the lambda diode is not critical. Almost any combination of n- and p-channel devices will work as well as those specified in the Parts List.

You may want to consider substituting a small relay for *LED1* to disconnect the battery pack from the load when the potential falls low enough to trigger the system. This setup will automatically protect the battery pack from polarity reversal during discharge. ◇

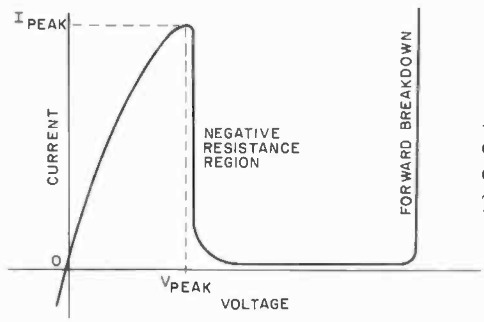


Fig. 2. Operating characteristics of the lambda-diode portion of circuit.

How To Choose a Heat Sink

BY THOMAS ZWASKA

THE purpose of using a heat sink for a power semiconductor device is to remove heat developed in the device so that the collector junction temperature remains below the maximum permitted—otherwise, the device may be damaged. To determine the proper heat sink for a given application it is necessary to find the maximum permissible thermal resistance from the collector junction to ambient air. The heat sink is then selected so that this maximum resistance is not exceeded. Here is a simple procedure to follow.

Design Information. The maximum power dissipated by a device is determined from: $P_D = (T_J - T_A)/\theta_{JA}$, where P_D is the maximum power dissipated by the device in watts, T_J is the maximum permissible junction temperature in °C, T_A is the maximum ambient temperature in °C, and θ_{JA} is the thermal resistance from junction to ambient in °C/W.

Most power transistors have a maximum junction temperature specified of 200°C. Designing for a lower temperature, say 20% to 40% less, will increase device reliability and life expectancy. The thermal resistance from junction to ambient is the sum of the individual thermal resistances: junction to case, θ_{JC}; case to heat sink, θ_{CH}; and heat sink to ambient, θ_{HA}.

The thermal resistance from junction to case depends on the style of the case. Some common values are:

Case	θ_{JC}
TO-3	1.5
TO-5	30.0
TO-66	4.0
TO-220	4.0

The thermal resistance from case to heat sink varies with the method of mounting. Factors involved include whether or not silicone grease is used, whether an electrical isolating washer is used, and the degree of mounting pressure used to hold the device to the heat sink. Here are some typical values:

Type of washer	θ_{CH} **no grease**	**grease**
none	0.2	0.1
beryllium oxide	0.4	0.2
anodized aluminum	0.5	0.3
mica	0.8	0.4

Procedure: Use the following steps: 1. Determine, by approximation, the maximum power dissipated by the device by multiplying the collector-emitter voltage times the collector current. For example, assume we have a series pass transistor in a voltage regulator whose output is 5 V at 2 A. The supply is 10 V, and the transistor is a 2N3055. Then the power dissipated is (10 − 5) × 2 = 10 watts.

2. Find T_J and θ_{JC} from the device specification sheet. For the 2N3055, T_J is 200°C, but we will decrease this to 150°C. From the table above, for a TO-3 case, θ_{JC} is 1.5.

3. Specify maximum ambient temperature. Assume 50°C.

4. Calculate maximum permissible $\theta_{JA} = (T_J - T_A)P_D = (150 - 50)/10 = 10$ °C/W.

5. Determine $\theta_{CA} = \theta_{JA} - \theta_{JC} = 10 - 1.5 = 8.5$ °C/W.

6. Determine θ_{HS} from type of mounting. With a mica washing and using grease, $\theta_{HS} = \theta_{CA} - \theta_{CH} = 8.5 - 0.4 = 8.1$ °C/W.

7. Select a heat sink having θ equal to or less than this value. In our example, we could use a Thermalloy 6002 which has a θ of 7.0°C/W. ◇

Experimenter's Corner

By Forrest M. Mims

THE PHOTORESISTOR

MOST experimenters turn to junction semiconductors like phototransistors and photodiodes when it's necessary to design a circuit which responds to light. *Junctionless* semiconductor photoresistors composed of cadmium sulfide and cadmium selenide, however, also have lots of applications. This month, we'll look at several.

First, let's review some of the characteristics of junctionless photocells. Figure 1 shows the spectral response of typical photocells made from cadmium sulfide (CdS) and cadmium selenide (CdSe). The former has a peak sensitivity in the green part of the spectrum (515 nm), surprisingly close to the peak response of the human eye (555 nm). Cadmium selenide peaks at 735 nm, in the red part of the spectrum.

Both CdS and CdSe photocells are exceptionally sensitive to light. They respond by changing their resistance by a ratio of as much as 10,000 to 1! This means a cell which has a resistance of a megohm in the dark may have a resistance of only a hundred ohms in bright light.

The two biggest drawbacks of photocells are slow response time and susceptability to fatigue. Phototransistors respond to a light pulse within microseconds and photodiodes within nanoseconds, but junctionless photoresistors require milliseconds or even seconds to respond to a light pulse. This, of course, means a CdS or CdSe photocell will ignore a brief flash of light a few microseconds long. Any phototransistor will easily detect such a flash.

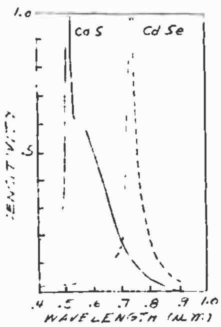


Fig. 1. Spectral response of CdS and CdSe photoresistors.

By fatigue (also known as the light memory or light history effect) we mean that the response of a particular photoresistor is governed to some extent by previous exposure to various light levels. This can be irritating, particularly if you're used to the more stable performance of phototransistors and photodiodes. When a photocell is used in a light meter, fatigue effects can be minimized by maintaining a reasonably constant light on the cell between measurements.

Now that we've covered some photoresistor basics, here are some practical applications you'll want to try.

Simple Light Meter. One of the most common applications for photoresistors is as sensing elements in light meters for photography. Figure 2 shows a simple light meter made from a CdS photoresistor, a 1-mA meter, and a low-voltage battery. Use any general-purpose CdS photocell with a high dark-to-light resistance ratio. You can connect the parts together with clip leads and have the circuit operating in a minute or two. But be sure the room lights are either off or very dim first. Otherwise the meter needle will swing over to its maximum

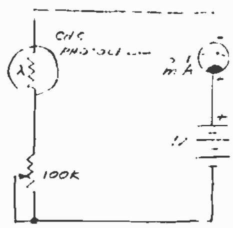


Fig. 2. Basic light meter.

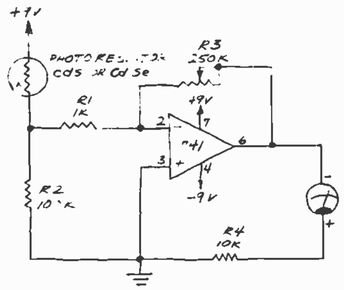


Fig. 3. Advanced light meter.

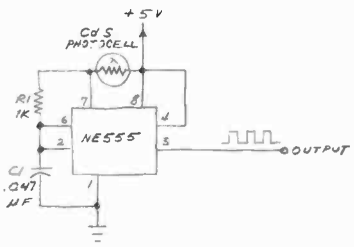


Fig. 4. A/D converter.

position and possibly be damaged.

After you connect the parts together, *slowly* point a flashlight beam toward the sensitive surface of the cell while watching the meter. As the meter needle responds to the changing light level, you'll gain a better appreciation of the sensitivity of the cell.

Incidentally, you can use a digital multimeter instead of a conventional meter if you prefer. This will eliminate the problem of accidentally slamming the meter movement and will also make reading the meter in the dark much easier. The digital readout, however, doesn't indicate changes as clearly as the moving needle of a conventional meter.

Advanced Light Meter. Figure 3 shows how to add an op amp to the simple light meter described above. The op amp gives the circuit exceptional sensitivity and permits easy calibration by simply changing the value of feedback resistor *R3*.

The circuit is so sensitive that it should be adjusted in the dark. Use a digital multimeter in place of the 1-mA meter or illuminate the meter scale with a "flashlight" made from a red LED in series with a 100-ohm resistor and a few 1.5-volt cells. Place the meter a foot or more away from the photocell to minimize the effect of light from the LED. Then turn off the lights and adjust *R3* for a meter reading of zero. For an impressive demonstration of the circuit's sensitivity, strike a match while watching the meter.

Analog/Digital Converter. Analog/digital (A/D) converters transform analog signals such as voltage levels into patterns of pulses which can be used in a digital circuit. Figure 4 shows an ultra-simple A/D converter which transforms a variable light level into a stream of pulses. The circuit uses a 555 timer connected as a light-sensitive astable multivibrator. When the photoresistor is in darkness, the pulse rate is about 1 Hz; when it is placed near a 60-watt lamp, the pulse rate jumps above 22 kHz.

Incidentally, this circuit also makes a handy audio light meter. Just connect a small 8-ohm speaker in series with a 220-ohm resistor between pins 3 and 8 of the 555 IC. Then darken the room lights and play a flashlight beam across the photocell's sensitive face and listen to the variable audio tone produced.

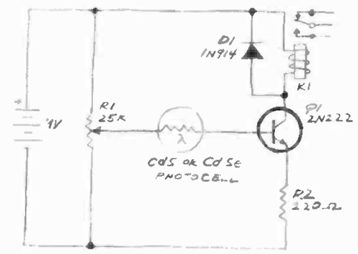


Fig. 5. Light-activated relay.

Light-Activated Relay. Finally, Figure 5 shows a simple but effective light-activated relay which uses only half a dozen components. As light falling on the photoresistor increases in intensity, *Q1* turns on and energizes the relay. *D1* prevents any high-voltage kick created when the relay coil turns on and off from damaging *Q1*. I used a 2N2222 for *Q1*, but any general-purpose npn switching transistor will work. Resistor *R1* serves as a voltage divider which sets the circuit's trigger point. ◇

Hobby Scene

By John McVeigh

TRANSFORMERLESS POWER SUPPLIES

Q. ***Do you have a circuit for a 12-to-14-volt, 3-ampere transformerless power supply? I want to use it to power an automotive AM/FM stereo radio indoors. I have tried several transformer types, but they are too noisy through the radio.—John Sumpolec, Jr., Las Vegas, NV.***

A. The use of "transformerless" power supplies is very dangerous. If the line cord is inserted so that the "hot" side of the ac line is connected to the power supply "ground," accidental electrocution could result. If one portion of your body is grounded, and you touch the power supply ground (directly or, say, by touching the "grounded" chassis of the radio), you will be placing yourself *directly* across the ac line! *Please* do not use transformerless, line-powered circuits. I can think of no reason why transformerles supplies should be any "quieter" than transformer supplies. Perhaps the noise you mentioned was ac hum. If that is the case, the supply had insufficient filtering. Try beefing up the capacitance of the ripple filter by several hundred or a thousand microfarads or so. That should smooth out the rectified dc and "quiet" the supply.

FINDING SUBSTITUTES

Q. ***In reading construction articles, I frequently come across parts descriptions including the phrase, "or equivalent." But I'm too inexperienced to decide when a component is equivalent to the printed type number. Are there any substitution sources?*** *—John Whelan, Miami, FL.*

A. There are a host of cross-reference works available at most electronics parts supply houses. Here are some examples: Motorola's HEP Cross-reference Guide and Catalog, and its Supplement No. 1; Sylvania's ECG Replacement Guide and Catalog; the RCA SK Series Replacement Guide; Radio Shack's Archer Semiconductor Reference Handbook; Howard W. Sams Co.'s Semiconductor Replacement Guide and its Transistor Substitution Handbook No. 14, and Tab Books' Tower's International Transistor Selector.

Also useful are the Radio Shack Quick-Fill Catalog, and a distributor's catalog such as those by Allied Electronics and Newark Electronics.

GUITAR PREAMP

Q. ***Do you have a circuit for a guitar preamp with active tone controls that would fit inside a guitar body? Also, I need plans for such devices as fuzz tone, phasors, wah-wah, and sustain.*** *—Dennis Colarelli, Arvada, CO.*

A. A phasor/flanger appeared in the June 1976 issue of POPULAR ELECTRONICS. For the other circuits, I would recommend "Electronic Projects for Musicians" by Craig Anderton. It's a 134-page (8½" × 11") soft-cover book, $6.95, and is published by Guitar Player Productions, Box 615, Saratoga, CA 95070.

USING AUTOPATCHES

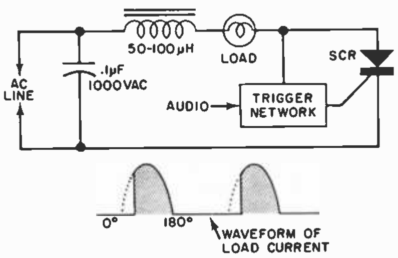
Q. ***I have a question in reference to the article "Tie Into Ham Repeaters With This Low-Cost Autopatch" in the November 1976 issue. How can you check into a local repeater? Is this keyed out over a CB channel? Where can we get more information about autopatches and repeaters?*** *—James Starr, Fort Wayne, IN.*

A. Repeaters and autopatches are not permitted on the Citizens Band Radio Service. The closest ham band that is open to repeater operation is the 10-Meter band. But this is a relatively recent development and I haven't heard any repeaters in the New York area. Most ham repeaters are located on the 2-Meter band (146-148 MHz), and some are on the 1¼-Meter (220-225 MHz) and ¾-Meter (420-450 MHz) bands, using the FM mode. If you're interested in learning about repeaters, consult "FM and Repeaters for the Radio Amateur" published by the American Radio Relay League, 225 Main Street, Newington, CT 06111. You might also check around Fort Wayne. I know that there's a repeater out there (on 146.16/76 MHz, I think), so there's probably a repeater club that maintains it. Club members can tell you all you want to know.

SCR NOISE PROBLEMS

Q. ***I bought an inexpensive color organ about a year ago. It worked well until I put 150-watt floodlights on it. Now I have intolerable interference. Is there any circuit to attenuate the noise?*** *—Michael Ethier, St. Paul, MN.*

A. The color organ uses SCR's to turn on the lamps. When the SCR turns on, it does so abruptly, generating the fast-rising waveform shown in the figure. This waveform is repetitive and is rich in harmonic energy. The larger the overall amplitude becomes (as when you switched to higher-powered bulbs), the more harmonic energy is present. You don't mention whether the interference is coming through your audio system or through a radio receiver. It might be both—the harmonics in the SCR switching waveform extend into the r-f region.



You can prevent the radiation of harmonics by installing an LC network across the ac line, and, if necessary, shielding the color organ enclosure. The LC filter will prevent the transient from propagating out along the power wiring, and the shielding will prevent radiation by element leads and wiring within the organ. A commercial "brute force" line filter can be used, or a wound coil and capacitor can be installed inside the organ. A 1000-V ac, 0.1-μF disc ceramic capacitor and about 70 turns of insulated wire on a ferrite core are suitable. One mail-order source of ferrite rods is Amidon Associates, 12033 Otsego St., No. Hollywood, CA 91607. Its 30-61-4 (4" × 0.5" dia. or 10.2 × 1.3 cm) and 30-61-7 (7.5" × 0.5" dia. or 19.1 × 1.3 cm) rods, priced at $2.50 and $1.50 respectively, are well suited for use in "hash" filters.

Have a problem or question on circuitry, components, parts availability, etc? Send it to the Hobby Scene Editor, POPULAR ELECTRONICS, One Park Ave., New York, N.Y. 10016. Though all letters can't be answered individually, those with wide interest will be published.

If you've been thinking Realistic is great only in the middleweight division, the STA-2000 is going to take you by surprise. We designed and manufactured it in our own factory to deliver quality beyond reproach, and judging from critical acclaim, we succeeded. The fine styling and precision controls are obvious. But the heart of this receiver is in its circuitry . . . the extra-low-noise phono stage . . . the sensitive dual-gate MOSFET tuner with PLL. Come by your nearby Radio Shack for a free copy of the reviews. And hear for yourself what all the excitement's about. You'll be amazed at just how far $499.95* can go. The Realistic 2000. 75 watts per channel, min. RMS at 8 ohms from 20-20,000 Hz, with no more than 0.25% total harmonic distortion.

"noise figures rivaling those of many a separate (preamp) . . . If any part approaches over-achiever status, it is the power amplifier . . . The controls are unusually flexible"

High Fidelity Magazine,
March 1977

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Audio Magazine,
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Product Test Reports

KRIS MODEL XL-50 40-CHANNEL CB MOBILE TRANSCEIVER

Features exceptional noise-blanker and agc operation.

THE NEW Kris Model XL-50 AM mobile, finished in black with chrome trim and white labelling, employs phase-locked-loop (PLL) frequency synthesis, the "standard" scheme in 40-channel rigs. Channels are indicated by large LED displays that make identification much easier to read than from a selector dial.

Among the special features to be found in the Model XL-50 transceiver, which is Kris' top-of-the-line mobile, are: three easy-to-read illuminated meters (S UNITS, POWER, and MODULATION level); separate dimmer controls for the numeric display and meters; RF GAIN and TONE control; intercom (INT) provision; jack for external S-meter accessory; and a large illuminated RECEIVE/TRANSMIT indicator. Other features include: VOLUME, SQUELCH, and DELTA TUNE controls; noise-blanker (NB), PA, and INT/EXT speaker switches; external speaker jacks; detachable dynamic microphone; electronic voltage regulators; and negative- or positive-ground power source operation.

The transceiver measures 9.5"W × 8.9"D × 3"H (24.1 × 22.5 × 7.6 cm). Provided with microphone and mobile mounting hardware, it's priced at $259.95.

Details and Performance. The double-conversion receiver section produces i-f's at 10,695 and 455 kHz. Except for an IC in the PLL system and another IC in the audio section, bipolar transistors are used throughout the receiver. As is usual, the r-f stage is diode protected and has single tuned input and output circuits. A double-tuned bandpass circuit couples the two mixers together to aid in the suppression of unwanted signals.

The performance of the front-end section of the receiver yielded a sensitivity of 0.5 μV for 10 dB (S+N)/N at 30% modulation with a 1000-Hz test signal. Image rejection measured 60 dB, i-f signal rejection was 70 dB, and other spurious signal rejection was between 45 and 60 dB. The latter was mostly due to overload "crossover birdies" in the area of the CB range.

Two ceramic filters are employed in the receiver, one at the input and the other at the output of the first 455-kHz i-f amplifier. This provides excellent selectivity. We measured a minimum of 60 dB rejection in adjacent-channel, desensitization, and cross-modulation tests. The overall 6-dB frequency response, including that of the audio system, was nominally 225 to 2450 Hz with the TONE control set to its midpoint. At the minimum and maximum settings, the response was 225 to 2000 Hz and 325 to 2800 Hz, respectively.

The audio section consists of a transistor squelch gate and an IC that contains the output amplifier that also doubles as the transmitter modulator. Maximum sine-wave output at the onset of clipping with a 1000-Hz test tone and an 8-ohm load was 3 watts at 1.4% THD (4% at 400 Hz) on receive and PA.

Amplified squelch and agc are employed. Squelch threshold range was 0.2 to 1000 μV. The agc was exceptionally flat, even at low signal levels. It held the audio output to within 1 dB with an r-f input change of 0.5 to 5 μV (20 dB), to 1.5 dB at 1 to 10 μV (20 dB), and to 3 dB at 1 to 10,000 μV (80 dB). The S meter indicated S9 with a nominal 50-μV signal. Meter readings dropped quite rapidly at lower r-f levels, requiring about 8 μV to produce any indication whatever.

The noise blanker employs three pulse amplifiers. It interrupts the output of the second mixer during each noise pulse. (It is switched in and out in conjunction with an audio noise limiter.) The overall combination provides outstanding impulse-noise attenuation, making it possible to "read" a 0.25-μV signal unhindered by noise pulses 100 dB above 1 μV/megahertz bandwidth.

The PLL system utilizes a second conversion crystal oscillator (10,240 kHz) from which the standard reference is also obtained by means of the PLL divider. The voltage-controlled oscillator (vco) functions as the first-conversion oscillator and operates in the range of 37 MHz. Its comparison signal is derived by a "down" mixer in conjunction with a 35.47-MHz crystal oscillator to create a nominal 2-MHz signal in the PLL divider. The divider is in an IC that apparently also contains the control voltage circuitry for the vco.

On transmit, the vco's output is combined with a 10,695-kHz crystal-controlled signal at the transmitter mixer. The mixer is followed by a bandpass filter, predriver, driver, and power-amplifier stages. The output is matched to 50-ohm lines with the usual double-section network where harmonic attenuation is augmented by a TVI filter. Antenna switching is accomplished with a relay.

Powering the transceiver from a 13.8-volt dc source, the carrier output measured 4 watts into a 50-ohm dummy load.

An automatic-modulation control (amc) system is derived from the second microphone preamplifier (there are two mike preamps) and consists of three cascaded compression amplifiers that control the collector-to-emitter resistance of a transistor that is shunted across the input to the first mike preamp, thus serving as an automatic volume control. It performed excellently.

With a 1000-Hz test tone and mike input levels 16 to 26 dB greater than that required for 50% modulation, positive-peak modulation went to just 100% and 90% to 95% on the negative peaks. The maximum 1000-Hz THD was 2.6% (6.25% at 400 Hz and 75% modulation). With dynamic operation and maximum voice levels, producing high average modulation, the negative-peak modulation occasionally exceeded 100% for an insignificant duration and to an insignificant degree. Adjacent-channel splatter, at more than ±5000 Hz from the carrier, was at least 60 dB down. The same was true in our tests with 1000- and 2500-Hz test tones.

The overall response of the transmitter, referred to 1000 Hz, was −6, +1, −6, and −10 dB at 300, 750, 1800, and 2500 Hz, respectively. The transmitter frequency tolerance was within 2 Hz of +50 Hz on any channel.

User Comment. The Kris XL-50, the first of a series of 40-channel rigs reported upon here, easily met the new FCC requirements. Furthermore, its r-f power output and modulation capability were as high as the FCC permits, which is the same maximum as in the 23-channel days.

Particularly impressive was the XL-50's noise-blanker operation in the face of high impulse noise. In a mobile situation, this will be translated into reading more weak signals than with many other types of NB circuits. Also high on the performance list is the exceptional agc operation, which maintains a constant audio output level (to the ear) in spite of gross signal-level changes. When one adds fine selectivity, improved adjacent-channel splatter, et al, we have an excellent example of how newly designed 40-channel transceivers are capable of providing superior performance to the older 23-channel rigs.

As Kris's premium mobile rig, there are convenience extras that are most welcome (and, of course, added to the selling price). The meters are easy to read under all conditions, while the modulation meter gives curious CB'ers an opportunity to approximate the amount of modulation (calibrated at the 50% and 100% points) they're putting out. This contrasts well to the more common indicator lamp that's really nothing but a peak modulation indicator. Also, the selector dial includes the channel numbers so that, in the unlikely event the LED numeric indicators should fail, the operator will still know which channel he's clicked into.

To conserve space, most of the rotary controls are concentric pairs to provide dual functions. Though we can appreciate the need for this on a trade-off basis, we don't particularly care for the idea. Other fillips include a speaker mounting location on the left side of the rig's enclosure that enhances voice intelligibility, the letters "PA" displayed on the numeric indicators when PA mode is activated and a RECEIVE indicator that glows green and a TRANSMIT indicator that glows red when the appropriate functions are used.

CIRCLE NO. 103 ON FREE INFORMATION CARD

YAESU MODEL FRG-7 COMMUNICATION RECEIVER

Moderately priced, 0.5-to-30-MHz receiver uses Wadley Loop design.

ONE CAN count the number of moderately priced general-coverage communication receivers on the fingers of one hand. So a rather new entry, such as the Yaesu Model FRG-7, is most welcome. Its 0.5-to-30-MHz tuning range covers standard AM broadcast, mediumwave, shortwave, amateur radio, and CB bands.

Called the "Frog 7" by SWL'ers, it's a triple-conversion receiver that uses a Wadley Loop design to inexpensively cancel drift from the variable oscillator. The all solid-state unit operates on ac line power and on 12-V batteries.

Rated sensitivity is 0.7 μV on SSB and CW and 2 μV on AM for 10 dB (S + N) /N. Selectivity is rated at ±3 kHz at −6 dB and ±7 kHz at −50 dB. After warmup, receiver drift is claimed to be less than 50 Hz in any 30-minute period. The maximum audio output power is specified at 2 watts into 4 ohms. Between 1.6 and 30 MHz, antenna impedance is stated at 50 ohms, while the broadcast band antenna input is a high impedance between 0.5 and 1.6 MHz.

The receiver has a carrying handle on the right side of its cabinet. It measures 13⅜"W × 11¼"D × 6"H (24 × 28.5 × 15.3 cm) and weighs 15.4 lb (7 kg) without batteries. Price is $299.

General Description. The main tuning dial covers a 1000-kHz range with calibration marks located at 10-kHz intervals. The band is selected by a smaller MHZ knob and dial, the latter with index marks and numbers at integral megahertz intervals over the full range of the receiver. Near the MHZ knob is a small red LOCK indicator that extinguishes only when the MHZ tuning is properly set. In operation, the readings of the MHz and main tuning dials are summed to obtain the frequency to which the receiver is tuned. Above the main tuning dial is a small signal-strength meter, and to the right of the control is a button that moves the dial index for calibration purposes.

The r-f amplifier is tuned by a separate PRESELECTOR control and dial that covers the full range of the receiver in four bands. The bands are selected by a BAND switch. The MODE switch has positions for USB/CW, LSB, AM, and AM/ANL (the last with built-in noise limiter). The ATT attenuator switch has a NOR center position for unattenuated signal reception and DX and LOCAL positions. The TONE switch, also a three-position affair, has NARROW, NOR, and LOW positions. In the NARROW position, the nominal frequency response is 400 to 2500 Hz, while in the LOW position, it is 250 to 1500 Hz.

Near the POWER switch is a separate LIGHT switch that turns on and off the dial and meter lights to conserve power when operating the receiver from batteries. In addition to its built-in ac power supply, the receiver has storage space for eight D cells that can be used for portable operation. Alternatively, the re-

Closeup of front-panel tuning controls including band selector, preselect setting, and MHz knob and dial. Main tuning dial covers 1000-kHz range. LOCK indicator goes out when MHz tuning is properly set.

ceiver can be powered from an external 12-volt dc source, such as a car battery. Any or all of the power sources can be connected to the receiver simultaneously. Receiver operation is automatically transferred to the various supplies with the ac power line taking priority, then the external dc source, and finally the internal battery system.

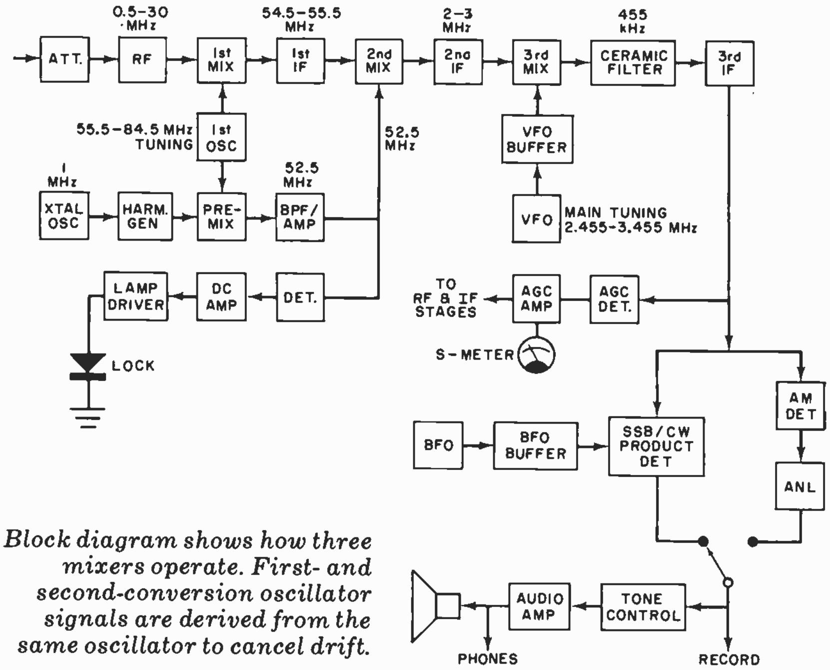
In addition to a PHONES jack on the front panel, there is a RECORD jack that carries the audio at a fixed level that is unaffected by the TONE switch or VOLUME control. Plugging into the PHONES jack silences the built-in speaker.

On the receiver's rear apron are spring-loaded clips for AM and shortwave wire antennas, ground, and muting. Grounding the last silences the receiver when transmitting. There is also a uhf coaxial connector for a shortwave antenna; it parallels the other SW connector. A socket is provided for connecting an external 12-volt dc power source. There is also a phone jack for an external 4-ohm speaker. (Using an external speaker via this jack silences the receiver's speaker.)

Circuit Description. From the antenna terminals and input attenuator, the incoming signal goes to one gate of a dual-gate MOSFET r-f amplifier (see block diagram). The signal then passes through a 35-MHz low-pass filter to the balanced first mixer, where it is heterodyned against a signal from the first conversion oscillator. This oscillator covers the range from 55.5 to 84.5 MHz, under control of the MHz dial. The output of the mixer is at the first i-f (54.5 to 55.5 MHz), where it is amplified by another dual-gate MOSFET. In the second mixer, an unbalanced circuit with a single FET, the signal is converted to a second i-f in the range of 2 to 3 MHz.

A novel feature is the manner in which the receiver's first- and second-conversion oscillator signals are derived from the same oscillator, so that any drift in the two conversions is cancelled. In the block diagram, it can be seen that the first oscillator output is mixed with a "comb" of signals derived from a 1-MHz crystal oscillator and a harmonic generator at 1-MHz intervals. The output of the "premixer" where this combination takes place is passed through a 52.5-MHz filter that uses four double-tuned transformers. Only that frequency is allowed to reach the second mixer, where it converts the 54.5-to-55.5-MHz first i-f to 2 to 3 MHz. As the first oscillator is tuned from 55.5 to 84.5 MHz, a 52.5-MHz signal passes through the filter to the second mixer at 1-MHz intervals. (The LOCK light extinguishes each time a 52.5-MHz signal appears to signify the system is functioning properly.)

Following the second mixer, the signal is further amplified by a dual gate MOSFET and converted to 455 kHz in a third FET mixer. The local oscillator for this conversion has a 2.455-to-3.455-MHz range and is highly stable and under the control of the main tuning dial. After passing through a 455-kHz ceramic filter and two stages of amplification, the signal is converted to audio in one of the two detectors. For SSB and CW, a four-diode balanced modulator is used as a product detector. The frequency of the bfo, which is used for this final conversion, is shifted by the MODE switch for USB or LSB reception. For AM reception, a simple half-wave diode detector is used. An IC audio amplifier drives the speaker or headphones. The automatic noise limiter (anl), which functions only on AM, is a diode-shunt type. A separate agc rectifier measures the signal level at the output of the 455-kHz i-f amplifier, and the resulting dc voltage is amplified and used to control the gain of the MOSFET r-f and i-f amplifiers and the deflection of the signal meter.



Block diagram shows how three mixers operate. First- and second-conversion oscillator signals are derived from the same oscillator to cancel drift.

Laboratory Measurements. The sensitivity of the receiver was measured at 2, 7, 14, and 28 MHz. It was exceptionally uniform over the entire frequency range, measuring between 0.9 and 1.1 μV for a 10-dB (S+N)/N ratio on SSB or CW, and from 2 to 3 μV on AM (using a carrier modulated 30% at 400 Hz). Selectivity was measured indirectly, by sweeping the frequency of the audio signal modulating our signal generator and plotting the receiver's audio output on a synchronized chart recorder. Although this includes the effect of any audio response shaping, it also shows quite clearly how the ceramic i-f filter cuts off the higher modulation sideband frequencies.

With the TONE switch at its normal setting, the response measured at the PHONES output was within ±2 dB from 20 to 1000 Hz (down 6 dB at about 1500 Hz). There was an abrupt drop in output above 3500 Hz, where the filter skirts begin to have an effect. With the NARROW switch setting, the response peaked broadly in the 500-to-1000-Hz range and was down 6 dB at 125 and 1900 Hz. In the LOW position, the response was fairly similar to NORMAL up to about 400 Hz; but it fell off rapidly to −6 dB at 900 Hz and −12 dB at 1500 Hz. At the RECORD output, the NORMAL response was flatter and presumably reflected the i-f response more accurately. It was down 6 dB at 2700 Hz and dropped much more rapidly above 3200 Hz. It should be noted that these measurements were made in the AM mode. In SSB, the effective audio bandwidth would be considerably greater, since the single sideband would be able to occupy most of the filter bandwidth, shared between the two sidebands in AM reception.

The antenna attenuator reduced signal levels by 10 dB in the DX position and by 20 dB in the LOCAL position. The S meter gave readings that bore little relation to the relative strengths of the signals. At 2 MHz, a 0.5-μV input gave a meter reading of S3, 0.8 μV gave S6, and only 1.1 μV, the level that also gave a 10-dB (S+N)/N reading, drove the meter to S9. The same generosity was evident at higher levels, with 1.7 μV yielding S9 + 10 dB, 9 μV equal to S9 + 20 dB, and 75 μV (which on most amateur receivers would be slightly more than S9) pushed the meter to an impressive S9 + 30 dB. Much of the time, the normal background atmospheric noise drove the meter to an S9 reading in the absence of a signal.

A triple conversion receiver is inherently subject to spurious responses, unless extraordinary precautions are taken in shielding and filtering. (Compensating for this is the fact that, due to its high first i-f, the FRG-7 is relatively immune to image responses.) The synthesizer technique used in the receiver gives a definite signal at every megahertz interval, corresponsing to 0 and 1000 on the main tuning dial. Fortunately, the signals are relatively weak and did not interfere with reception of WWV, for example. We also found a large number of weak "birdies" spaced about 140 kHz apart, principally in the 26-to-30-MHz range. Although audible with no antenna connected, they were too weak to interfere with normal reception. However, at lower frequencies we found several rather strong spurious signals, principally at 2730, 3240, and 22,370 kHz, with amplitudes registering from 10 to 30 dB over S9 on the receiver's meter.

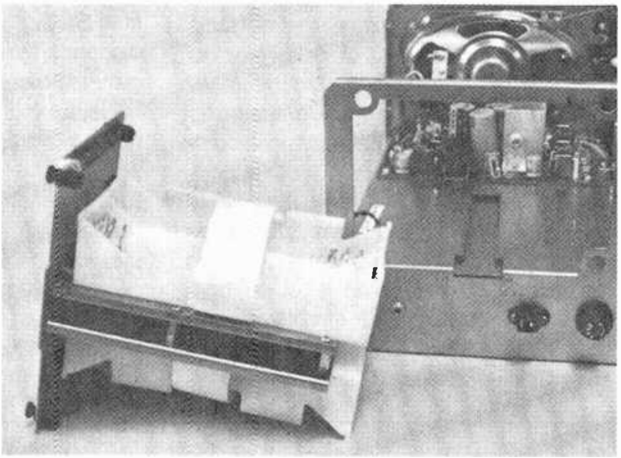


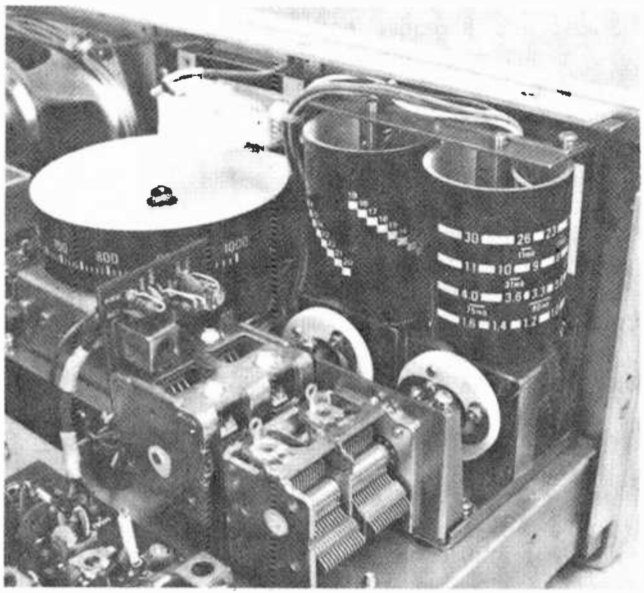
Photo of the Yaesu receiver with the battery holder removed from case.

We checked the degree to which the receiver was desensitized by strong signals out of its immediate passband. When the interfering signal was 50 kHz from the station being received, a 1000-μV level produced an audible reduction in signal strength. At 100-kHz spacing, the required strength was 5000 μV. A 10,000-μV signal desentized the receiver at any spacing from 150 to 1000 kHz. (We did not check this with a signal in an adjacent band.)

The dial calibration, when set against WWV at either end of the main tuning dial range, was accurate at the other end as well. Between these limits there was a slight calibration nonlinearity, evidenced by a 10-kHz error on CHU at 7335 kHz. Since the receiver lacks an internal crystal marker oscillator, there is little that can be done about this, although it should not bother most shortwave listeners. Any frequency drift that might have occurred during operation was insignificant, and the receiver was fully usable from a cold start. The audio output was about 1.5 watts into 8 ohms and 1.7 watts into 4 ohms. If more distortion could have been tolerated, the rated 2-watt output could easily have been realized.

User Comment. For the SWL, this receiver offers an appealing combination of sensitivity, selectivity, accurate dial calibration, and modest price. It is easy to tune, and the quality of the sound was good.

The amateur operator will not be so well served. The ceramic i-f filter is too broad for today's crowded bands, either for CW or SSB reception. Moreover, if the receiver is located too close to a powerful transmitter, such as another amateur or a broadcast station, trouble might be experienced from desensitization. The 20-dB LOCAL attenuator will



Rear view of preselector and MHz dials.

help cope with this problem. Our test receiver's main tuning was free of backlash in the lower third of its range, but had a "rubbery" action toward the upper part of the scale that made tuning of SSB signals difficult. Unlike most communication receivers designed specifically for the amateur market, the FRG-7 does not give "single signal" reception of CW signals. Signals are audible at approximately the same level on both sides of zerobeat, which effectively doubles the QRM level in reception. The agc is not defeatable and has a time constant that we feel is too short for comfortable SSB reception, where it produced a disconcerting "pumping" of the background noise level.

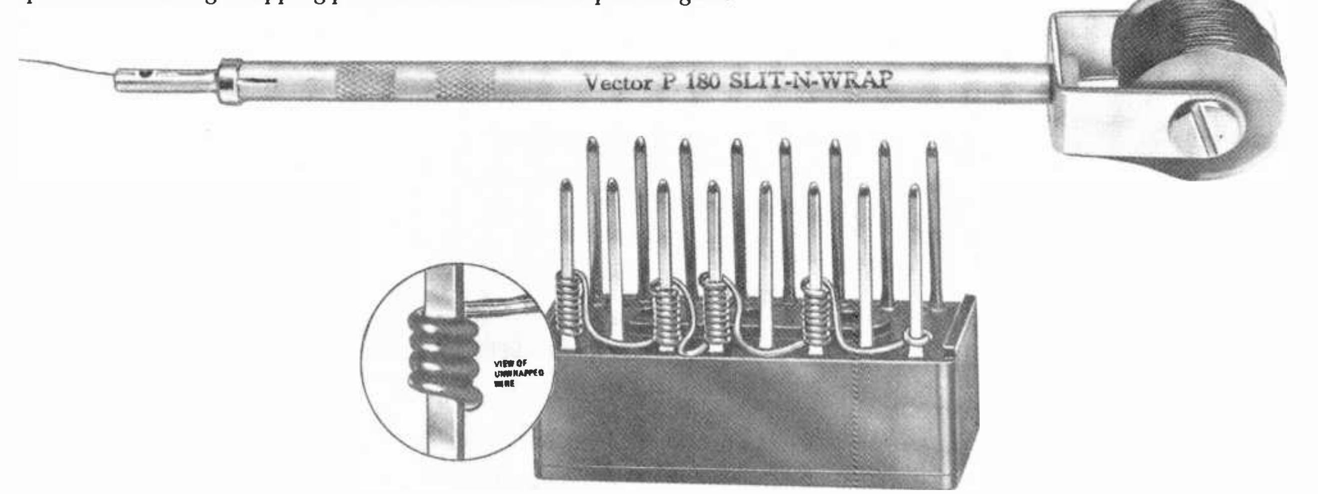
Useful extras for the SWL such as a noise blanker, notch control, switchable agc, crystal calibrator, etc. are absent. But they are not expected in this price range. Also, the "S" meter on our sample was useless as an indicator of incoming signal strength—every receivable signal registered better than S9, which is a handicap when seeking acknowledgement (QSL) cards.

Despite these criticisms, we found much to admire in the FRG-7. It is handsome, ruggedly built, on the whole very smooth-handling, and is rock-stable (even against pounding on the cabinet). SWL's who have attempted to use some of the lower-priced general-coverage superheterodyne receivers, plagued by drift, images, and useless calibrations, will be in for a pleasant surprise when they try this receiver. Considering what it offers, the Yaesu FRG-7 is a good value at its price.

CIRCLE NO. 104 ON FREE INFORMATION CARD

VECTOR "SLIT-N-WRAP" WIRING TOOL

Exposes wire during wrapping process to allow shorter post lengths.



THE POPULARITY of Wire Wrapping is growing by leaps and bounds, not only for original circuit prototyping but for final project wiring as well. The Wire Wrap technique is simple, fast, and reliable. Since it requires no soldering to assure electrically and mechanically sound joints, it readily lends itself to easy circuit modification. A number of Wire Wrapping tools have come on the experimenter/hobbyist market in recent months, one of which is the Vector "Slit-N-Wrap" tool.

Most Wire Wrapping tools require the wire to be cut to length and the insulation to be stripped away from both ends before wraps are made. What makes the Slit-N-Wrap tool different is that it eliminates these time-consuming requirements, thanks to a built-in slitting edge that exposes bare wire to the wrap posts during the wrapping operation. This slitting edge also makes it possible to make "daisy-chain" connections to a number of posts with a continuous, unbroken length of wire in wiring-pencil fashion. Hence, post length can be reduced to conserve space with the Slit-N-Wrap technique.

The Slit-N-Wrap tool is available in two models. The manual Model P180 tool that sells for $24.50 comes with instructions, No. P183 forming tool, and two 100′ (30.5-m) spools of 28-gauge wire. The cordless, battery-powered Model P160-4T comes with the Model P180 tool installed, two spools of wire, No. P183 forming tool, trickle charger, and instructions and sells for $60.00. Replacement spools, each containing 100′ of wire (with green, blue, red, or clear insulation), are available for three spools for $2.75.

General Details. The Model P180 Slit-N-Wrap tool resembles a slender steel ballpoint pen with a small spool of wire at the top. The wire feeds from the spool, down through the hollow steel body of the tool, and exits through a hole in the tool's tip. The built-in slitting edge is located near the exit hole.

As the wire is wrapped around a wrap post, the slitting edge cuts through the insulation so that bare wire contacts the post. The remainder of the insulation on the wire remains intact. No slitting occurs when the wire free-feeds through the hole, only when a wrapping operation is being performed.

The wire used with the tool is 28 gauge and has a thin but very tough insulation. Aside from being used for Wire Wrapping, it can also be tack soldered to copper traces on printed circuit boards or crimped around solder posts and lugs and soldered directly through the insulation. There is no need to strip away insulation to form a soldered joint; the insulation vaporizes when soldering heat is applied to it. The No. P183 forming tool and chisel knife that comes with the Slit-N-Wrap tool is used as a routing aid and for cutting wires close to the wrap pins and pc board traces.

User Comment. For our tests, we used the manual version of the Slit-N-Wrap tool. (The manual and battery-powered versions of the tool are identical except that the latter eliminates most of the operator effort involved in wrapping.)

The first test to which we put the tool was in modifying our computer, which gave us an opportunity to test both the wrap and unwrap functions of the tool. We found the Slit-N-Wrap tool to be as easy to use as any other Wire Wrapping tool we have used in the past when it came to simple two-post runs. The tool excelled on daisy-chain runs and reduced what would ordinarily have been hours of cut, strip, and wrap to slightly more than a half hour of work. All our wrap connections were "perfect." What is equally important is that all our unwraps were accomplished without difficulty and left us with wire ends that could be wrapped like new.

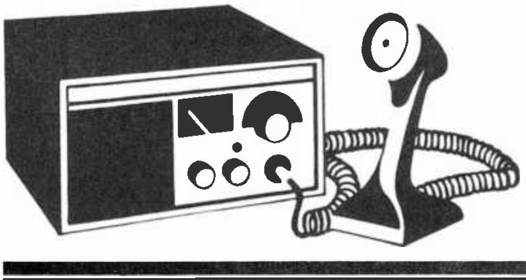
Next, we decided to see if we could verify Vector's claim that the typical post-to-wire contact resistance was approximately 3 milliohms (0.003 ohm). To do this, we made up three daisy chains, each consisting of 10 wraps in series. Then, after nulling out the resistance of the test leads on our high-accuracy, laboratory-grade digital multimeter, we measured the total resistance of each daisy chain. Our readings of 0.0301, 0.0307, and 0.0308 ohm, when divided by 10 to obtain the average single-contact resistance, tallied very closely with Vector's claim.

In our tests for tack soldering the wire to pc traces and solder lugs directly through its insulation we noted that 27½-watt heating elements tended to char the insulation instead of vaporizing it. However, when we switched to the 37½-watt heating element we normally use in our soldering iron, the insulation almost instantly vaporized and allowed us to make excellent soldered connections.

For a final test, we selected ten of the wraps we had made for our resistance test setup and unwrapped and closely inspected the slitted wire under a magnifying glass. In all cases, the slits were neat and clean. The insulation had parted neatly during the wrapping operation, as evidenced by the clean and well-defined "bites" in the wire from the posts.

Our experience with the Vector Slit-N-Wrap wiring system has made us a firm believer in this new tool. We would not hesitate to recommend the tool to anyone, amateur experimenter or professional technician or engineer, who does a lot of project building, prototyping, and circuit modification. It will pay for itself in time saved and frustration avoided.

CIRCLE NO. 105 ON FREE INFORMATION CARD



CB Scene

By Ray Newhall, KWI6010

CB-RELATED TVI—AND WHAT TO DO ABOUT IT

THE NEW FCC Rules make it the CB'ers responsibility to eliminate all television interference which results from transceiver emissions outside the authorized frequencies (26.965 to 27.405 MHz). These Rules apply and are enforceable, even though the CB'er can prove that his rig conforms with the technical specifications set forth in the Rules at the time of manufacture.

All transmitters and receivers radiate some harmonic and other spurious emissions. How, then, can the CB'er meet this requirement and still continue to operate?

Causes of TVI. In only about 20% of reported TVI cases has the cause of the problem been in the CB rig or the operating habits of the CB'er. In these cases, nearly always the CB'er is operating his rig illegally—say, by overmodulating—or has inserted devices in his antenna lead which generate harmonic energies not present at the output of the CB rig itself. In any case, the CB'er should work with the complaining TV viewer to determine what remedies are needed and where they must be applied.

Once it has *positively* been established that the TVI occurs when a particular CB transmitter is in use, it must be determined which TV channels are affected when the CB push-to-talk switch is pressed. TVI caused by a CB signal will normally cause the picture to fade, or cause cross hatching or parallel lines across the screen. (In no case can TVI which affects the TV audio be attributed to the CB transceiver.)

If the TVI appears on channel 2, or on both channels 2 and 5, but no others, there is a strong possibility that the CB station (the transmitter *and* its antenna system) is at fault. If the TVI appears on other channels as well, the television receiver is most likely the culprit. These rules will apply almost without exception. However, in an apartment or condominium where there is a common TV antenna system in use, the master distribution amplifier (if overloaded by the CB signal) can generate harmonics of the CB output. Seemingly, the CB transceiver is at fault. As a double-check, remove an affected TV receiver from the master system and connect it to an indoor antenna. If the TVI still appears only on channels 2 and 5, look to the CB rig for the cause.

Harmonics. TV channel 2 is located at about 54 MHz, which is just double the frequency of the 27-MHz CB. Almost every r-f generator (such as a CB transceiver) will produce signals at multiples of the primary oscillation frequency. But FCC Regulations impose strict limitations on the strength of harmonics radiated by the transceiver either through its cabinet or into the antenna line. If these harmonics pass beyond the reach of the rig's filters, there is *nothing* that can be done to suppress them at the TV receiver. Those are the very frequencies that the receiver is designed to accept, and an attempt to reduce their strength at the receiver would merely result in a loss of the desired TV signal. Conversely, if the receiver cannot reject fundamental CB signals at 27 MHz, then there is nothing that can be done by the CB'er to eliminate the TVI. Unfortunately, some TV manufacturers do not include sufficient filtering to reduce the receiver's vulnerability to strong radio signals removed from the TV channel frequencies. In the past, legislation has been proposed in Congress to require TV manufacturers to include such filtering but the bills expire before any action is taken. In response to the growing RFI problem and the apparent need for minimum electromagnetic compatibility standards for home-entertainment devices, similar bills are expected to be introduced in this session of Congress.

Remedies at the Receiver. In most cases, the TV receiver's susceptibility to overload by CB signals can be compensated for without extensive modifications. There are commercially available high-pass filters which can be attached at the antenna terminals at the rear of the TV. They prevent the CB signal from reaching the TV tuner. In severe cases, the filter might have to be mounted inside the receiver cabinet at the tuner's antenna input.

Many TV manufacturers will provide such filters free of charge to their customers who experience TVI. Alternatively, they might provide information on how TVI may be eliminated.

Remedies at the Rig. In the case of harmonic interference, if the CB'er is using a type-accepted rig that has not been modified in any way, chances are that the problem lies between the transmitter antenna terminals and the antenna itself. If the CB'er is using an illegal "linear," there is a good chance that he

REACT "Help" Flag

A special flag for motorists in distress is being distributed by local REACT CB teams. The REACT "Help" Flag is made of highly visible orange reflective vinyl, with the word "Help" and the REACT emblem printed in black. All CB'ers who see these flags on a disabled vehicle are asked to call their local REACT teams on Channel 9. The flag identifies a motorist in distress who wants assistance through CB radio. To obtain a flag, contact your local REACT team, who are distributing them as a combined community service and local fund-raising project, or send a donation of $5.00 or more to REACT International, Inc., 111 E. Wacker Dr., Chicago, IL 60601.

is causing severe TVI to at least 95% of the TV receivers within ¼ mile of his station. But linears are not the only cause of TVI. Any device introduced into the antenna feedline between the transceiver and the antenna has the potential of introducing harmonic radiation not present at the *transceiver*. Some linear amplifiers can increase harmonics by as much as 9 dB even when turned off. Coaxial switches and SWR meters can also introduce harmonics which might cause TVI. Any poor or corroded connections in the transmission line or at the antenna itself can cause TVI.

The CB'er with a TVI problem should first go to work on his antenna system, checking the SWR with a reflectometer. If the antenna system is at fault, it should exhibit an SWR of 3:1 or more. Make sure that the antenna lead shield is grounded at both ends and that all connections are clean and solid. Check the dc resistance to see that it is very low (4 ohms or less). Be certain that the coaxial cable is high-quality RG-58/U or RG-8/U, and that its outer vinyl jacket has not deteriorated. Examine the antenna for corrosion. If necessary, clean and weatherproof all connections and hardware.

If the antenna and feedline check out OK, and the TVI is still present, the CB'er should suspect the rig itself. Take it to a qualified, licensed technician for a thorough examination. Installation of a low-pass filter at the transceiver output can suppress any internally generated harmonics.

Two of the top enforcement priorities of the FCC are to locate and confiscate overpowered, illegal transmitters, and to reduce CB-caused TVI. They know that wherever there is a concentration of TVI complaints, they can probably fulfill both priorities at once. You can be reasonably certain that, sooner, or later, there will be an undercover RDF vehicle on the block.

For a free information kit on TVI, send a stamped, self-addressed envelope to Box 21, Hartford, CT 06103.

More About TVI Filters. The PURAC Task Group on Local Interference is currently conducting laboratory tests on all types of TVI filters. Preliminary tests have shown some to be very effective in controlling TVI, while others are nearly useless. This group is currently compiling a list of commercially available filters which meet its approval criteria. All filter manufacturers are invited to submit samples of their products for testing by the FCC-sponsored group. ◇

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There is no doubt television repair can be an interesting and profitable career field. TV repair, however, is only one of the many career areas in the fast growing field of electronics.

As an indication of how career areas compare, the consumer area of electronics (of which TV is a part) makes up less than one-fourth of all electronic equipment manufactured today. Nearly twice as much equipment is manufactured for the communications and industrial fields. Still another area larger than consumer electronics is the government area. That is the uses of electronics in such areas as research and development, the space program, and others.

Just as television is only one part of the consumer field, these other fields of electronics are made up of many career areas. For example, there are computer electronics, microwave and satellite communications, cable television, even the broadcast systems that bring programs to home television sets.

As you may realize, career opportunities in these other areas of electronics are mostly for advanced technical personnel. To qualify for these higher level positions, you need college-level training in electronics. Of course, while it takes extra preparation to qualify for these career areas, the rewards are greater both in the interesting nature of the work and in higher pay. Furthermore, there is a growing demand for personnel in these areas.

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MAC'S SERVICE SHOP

Basic and New Soldering Techniques

BY JOHN T. FRYE

BARNEY was working on a small pc board, his brow wrinkled in concentration. He was vainly trying to unsolder a transistor from the board without burning another component or creating solder bridges.

"Here," Mac said, handing him a slender gray-cased object with a red slide switch on the top and a short metallic rod protruding from the end. "Try this."

"What's this?" Barney asked suspiciously. "It looks like it might suck eggs."

"It's Weller's Model WC100 cordless soldering iron, one of a breed of portable irons introduced by a few manufacturers. It weighs 5¾ ounces and is only 6⅞ in. long without the interchangeable tip. Four tips are available; a regular, a fine point (which is in there now), a long reach, and a miniature which has an extra fine point. The tips, less than 1/5" in diameter, are made of nickel-plated copper. Each is ceramic-cemented to a stainless-steel tube that is Teflon-insulated inside and serves as a concentric path for current to the tip. These sturdy stainless-steel shanks also give the tips a degree of rigidity to inhibit bending during soldering.

"The WC100 comes with a wall-socket charger to keep its NiCd batteries charged. The cord from the charger plugs into a jack on the rear of the iron. Weller says that completely discharged batteries can be recharged in 14 hours, after which 50 to 100 pc board connections can be made before another recharging. For bench work, the charger can be connected continuously without over-charging or shortening battery life."

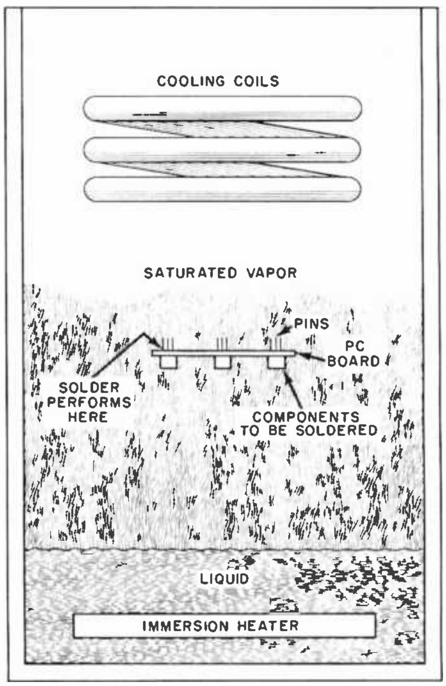
While Mac was talking, Barney had easily unsoldered the transistor. The tiny tip and the built-in worklight just below the tip shank made it easy to put the heat precisely where it was needed.

"Hey, this little rascal has plenty of oomph!" Barney exclaimed.

"That's right. It starts melting solder in six seconds and attains a tip temperature of 700°F (370°C) which is almost twice the temperature needed to melt 60/40 solder."

"Do you think it will replace our conventional irons and solder guns?"

"No, but it will supplement them. Just as we have a wide array of screwdrivers for different jobs, we also need several different soldering tools to work on today's electronic equipment. The important feature of the battery-operated iron



Mac's sketch of condensation soldering system shows how boiling liquid is heated to form saturated vapor. When the vapor condenses above, the latent heat of vaporization melts solder.

is its portability. It's not tied to a wall socket so it can be used in a car, on top of a TV tower, or anywhere that ac line current is not available. Of course, it has limitations. It's specifically designed for pc boards, jewelry, or small-diameter wires. It is not capable of performing heavy-duty continuous soldering. A tip only a little larger than a match head doesn't store up much heat! Getting maximum efficiency out of this little iron calls for a sharpening up of our soldering techniques."

"How's that?"

"When we have a large surplus amount of heat available, as we do with a heavy-duty iron or a gun, we can get by with sloppy soldering procedures—insufficient cleaning of the joint, failure to keep the iron properly tinned, melting the solder on the iron instead of the heated joint, etc. By using far more heat than necessary, we are able to make a fair joint by brute force. This won't happen with the small battery-operated irons. When using them, we must make the most of every watt."

The Right Way to Solder. "For example, with the small irons, we use only high-quality 60/40 solder that has a flow temperature very close to the ideal 361°F (183°C) of the eutectic 63/37 tin-lead alloy. As the alloy moves away from this eutectic point, more and more heat is needed to transform the solid solder into a free-flowing liquid. Also, with small irons, we use 19- or 21-gauge small-diameter solder to insure that most of the heat from the tip goes to the joint instead of being heat-sinked into the roll of solder. Further, we will make sure every joint is really clean before soldering. If at all possible, we'll arrange things so the iron can be applied below the joint. In this way, convection currents will carry the heat up and over the joint. Finally, we'll observe the "Golden Rule" of solder: *Apply the flat face of the adequately heated soldering iron directly against the assembly and simultaneously apply the solder at the exact point of iron contact.*"

"What's wrong with melting the solder on the tip and transferring it to the joint?"

"To appreciate the error in this common procedure, you must understand the functions of the solder flux. The flux—usually an activated rosin—cleans off the solder-repelling oxide that forms on all metal surfaces, but it can only do so in its corrosive hot liquid state. When cool, rosin is chemically inert and has an electrical resistance in excess of 3300 trillion ohms per cubic inch. The flux's other function is to lower the surface tension of the liquid solder and make it flow over and through the joint. Properly fluxed solder will actually flow against gravity to penetrate a small crevice by capillary attraction.

"Keep in mind that making a solder connection is not just a matter of sticking two pieces of metal together with a kind of conducting glue. There is actually a complex chemical action taking place. After the melted flux has cleaned off the corrosion on the metal surfaces, the solder wets and penetrates these clean areas and actually dissolves very thin layers of the juxtaposed metals so that they form an alloy with the solder. They thus unite with each other as an alloy that is partially solder and partially the joined metals. Ideally, this alloyed layer is only 0.004 in. (0.1 mm) thick. Any solder added after this alloy has formed is both superfluous and wasteful.

"Now, let's get back to what's wrong with carrying the molten solder to the joint on the tip of the iron. The rosin core of the solder is very volatile. You can see it evaporating into blue smoke when you touch a hot iron to a piece of solder. When this happens, the flux has dissipated itself on the tip long before you reach the joint, so you have solder with no flux. The solder may surround the oxidized surfaces of the wires, but it cannot wet and penetrate them by itself. The result is a mechanically poor, high-resistance joint."

"OK, I'll follow the Golden Rule no matter what soldering instrument I use," Barney promised. "Manufacturers of electronic equipment must certainly go by the book. Considering how many of their solder joints we look at, it's amazing how few poor connections we find."

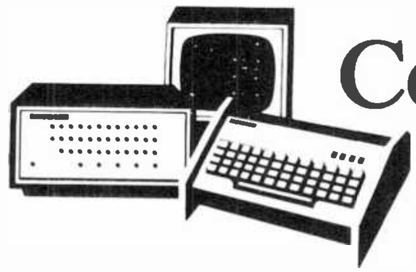
Commercial Techniques. "True. They've found that following sound soldering principles pays off. Of course, their mass-soldering methods are much different from those we use, especially with pc boards. We've talked about dip-soldering and wave-soldering before; but recently I read in Western Electric's *The Engineer* about some new and very intriguing methods of mass-soldering.

"One of these is solder fusing with forced convection liquid heating. One problem associated with pc boards is solder slivers. They result from the undercutting of electrode-deposited solder used as an etch resist during copper removal. Unless removed, they can short circuit pad layers in multilayer circuits. The slivers can be eliminated by raising the board temperature to about 410°F (210°C) and holding it there for about 30 seconds. One way to do this is with radiant heat, but heating a multicircuit board uniformly without exposing heat-sensitive components to excessive heat is difficult. Heat shields can be used, but they are expensive. Forced convection heating with hot air is also used, but it requires longer exposure to heat and may also require baffles to protect low-mass areas from excessive temperatures. Immersing the board in a heated fluid, such as glycerol, avoids most problems encountered with the other two methods and provides excellent temperature control, but glycerol requires very careful handling.

"A new method, called condensation soldering, is now being used not only to eliminate solder slivers but also to perform 'reflow soldering.' In this procedure, rosin-coated solder preforms shaped like little doughnuts are placed over the tops of pins to be soldered to the plated-through holes in the pc board. When the temperature is raised sufficiently, the solder melts and flows along the pin through the plated hole and forms a solder fillet. If the temperature can be precisely controlled, the distance the solder travels along the pin can be easily adjusted—a factor to be considered when the protruding end of the pin will be connected in an automated Wire-Wrapping process. For a good connection of this type, which is common in telephone work, there must be no solder under the wrapped wire—which rules out wave or dip soldering.

"Condensation soldering is accomplished very easily. In simple terms, a tall, open-topped vessel contains a liquid, say fluorinated poloxypropylene, which is brought to its boiling point of 436°F (224°C) with immersion heaters. When a relatively cool object such as a pc board with solder preforms is placed in the saturated vapor, which rises to the top, the vapor condenses uniformly on the object, releasing the latent heat of vaporization. A very high heat transfer rate is associated with this phase change, so the heating process is quite rapid. In fact, 20,000 solder connections have been made simultaneously in 60 seconds with this contamination-free process."

"Wow," Barney said. "All I needed was a little help unsoldering that transistor, and I got an introduction to a new type of soldering iron, a refresher course in good soldering techniques, a lecture on the functions of solder flux and the real nature of a solder joint, and finally a description of some methods of mass soldering. That will do me for today." ◇



Computer Bits

By Leslie Solomon

SOME NEW HARDWARE AND SOFTWARE

THE MARKETPLACE is so loaded with enticing material (hardware and software) for the computer hobbyist—with more being introduced all the time—it's getting so he hardly knows where to start. The "well-known" hobby computer manufacturers are doing their best to introduce new products on a regular basis; and many new firms are starting to spring up. Once the hobbyist gets things under way, however, there is enough equipment available for him to build up a really powerful personal computing system.

This month, let's take a look at some of the more recently introduced items that are available.

Printers. This seems to be an area of great interest to most hobbyists, as reasonably priced hard-copy devices are scarce. The Digital Group (Box 6528, Denver, CO 80206; Tel: 303-861-1686) has a kit for $495 for an interface card and a printer that produces 120 characters per second, 96 characters per line, 12 characters per inch horizontally by 6 lines per inch. This printer can make up to four copies simultaneously. The character set and pitch are variable under software control and allow for double-width characters, different-width characters in the same line, etc. The printer uses a 5×7 matrix and the ribbon has built-in re-inkers for an expected life of 10-million characters. The paper is standard 8½" roll, fanfold, or cut page, and the system interfaces via an 8-bit parallel port.

Video Displays. If you have an Altair-bus system, take a look at the VB1 Video Board from Cybercom (Solid State Music, 2102A Walsh Ave., Santa Clara, CA 95050; Tel: 408-246-2707). This $189.95 kit ($269.95 assembled/tested) video board features cursor, video reverse and graphics under software control, a selection of either 32 or 64 characters per line, 16 lines, upper and lower case with Greek alphabet and interchangeable fonts, matrix graphics, and parallel and composite video outputs. It can be addressed as 1k memory block.

Interactive Systems (Box 335, Jamison, PA 18929) is offering a pair of display units. The CDU-3216 (kit $155, assembled $189) is a 32-character-per-line, 16-line device with a 2-page capability; and the CDU-6416 (kit $195, assembled $220) is a 64-character-per-line, 16-line device with a 1-page capability. Both units have full cursor control and are contained on a single 9½" × 9¼" pc board and require a single +5-volt supply. Input data is 7-bit parallel and will load at an 80k-bit rate. The carriage return-line feed control characters are decoded and there are six spare codes that can be user defined.

From up Canada way, Matrox Electronic Systems (Box 56, Ahuntsic Stn., Montreal, Canada H3L 3N5; Tel: 514-481-6838) is now making available its MTX-1632SL ($225), a RAM-like video display device that produces 32 characters per line on a 16-line format, and "looks" like a conventional 512×8-bit RAM. The 128-character set features a 7×9 matrix with upper and lower case. Since each character on screen corresponds to a memory location, the full power of the computer is available for data display manipulation. The device requires no external refresh and has a 550-nanosecond access time, TTL compatibility, character blinking, and uses a single +5-volt supply. A unique feature of this video system is that it accepts external H and V sync that allows the display to be locked to any external sync source for video titling, and other uses. The system output is conventional video.

Mass Storage. Micro Designs Inc. (1175 Colusa Ave., Berkeley, CA 94707; Tel: 415-526-7794) has introduced a pair of new digital cassette mass storage systems with up to 1-megabyte(!) memory. Each of these systems features complete file management software that allows the user to manipulate both symbolic and binary files with high-level commands. The Model 100 ($550) uses a single cassette drive and stores ½-megabyte of data. The disc-like format allows access to any 128-byte record, the data transfer rate is 1000 bytes per second, and the tape can be searched at rates faster than 120"/second. The Model 200 ($825), featuring dual transports, puts one-megabyte on line.

Both units come assembled and ready for installation in an Altair bus. To bring up the operating system, the user loads a cassette, and transfers control to a ROM on the interface board. All further operations are automatic. Status lights keep tabs on relevant tape conditions, and hardware error detection is provided as well.

Z-80 Stuff. Technical Design Labs, Inc. (Research Park, Bldg H, 1101 State Rd., Princeton, NJ 08540; Tel: 609-921-0321) announces a Z-80 CPU card ($269) that is compatible with the Altair bus, and is designed to replace the current 8080 or 8080A CPU's. There are two on-board clocks—one crystal controlled and the other variable from dc to well beyond the limits of the Z-80. The use of the Z-80 dynamic refresh capability is made by bringing this signal out to the bus, making possible simple and inexpensive dynamic memory designs.

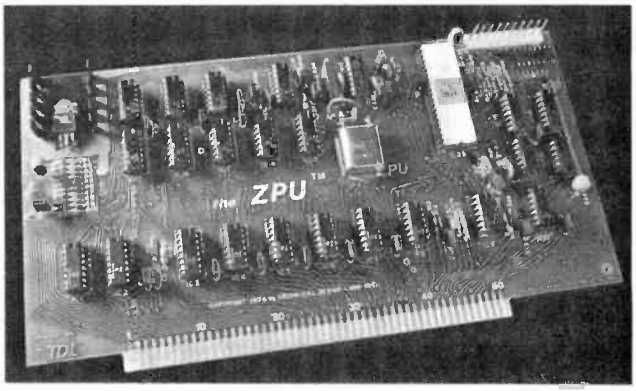
The pc boards are made from FR4 epoxy, with full solder mask and silk screen, all IC's are socketed, and each package contains full documentation including the Zilog Z80 manual, as well as the 1k Monitor and source code.

Also available from this same firm is their line of ZAPPLE software for the

Interactive Systems' CDU-3216 is one of two new display units.

Z-80. Five software packages are currently available at $150 each, with complete user's manuals. Monitor documentation includes the source code so that the hardware independence feature of Zapple software may be fully realized.

The Zapple Monitor occupies 2K of RAM and offers 27 instructions which includes full program debug capability, I/O handling, and modular organization to allow expansion with user-provided routines. The Zapple Text Editor occupies 3k of RAM and is both line and character oriented, which allows maximum user freedom in text manipulation as well as speed improvement over similar 8080 editors. The Zapple Re-locating Macro Assembler occupies 8k of RAM and features the ability to generate fully relocatable object code, allows infinite nesting of Macros, and many other features. A linking loader extension will soon be available. Zapple Basic occupies 8k of RAM and features all "normal" commands, including complete text editing facility, a List Variables statement that allows internal variables to be observed and/or modified during execution, a trace command that displays line numbers while they are being executed, and a renumber command to allow line number change according to any starting and interval parameters. Zapple Script is a word processor that occupies 3k of RAM or ROM and allows complete word processing capability including automatic paging, justification, concatenation, spacing, titling, and subtitling, and other formatting functions.



This ZPU card from Technical Design Labs. Inc., is compatible with the Altair bus.

Some New Software. Binary Systems Inc. (634 S. Central Expressway, Richardson, TX 75080; Tel: 214-231-1096) has introduced a new interpreter program for 8080 machines. Called BASIC ETC., the new interpreter was co-developed by John Arnold and Dick Whipple, authors of Tiny BASIC.

BASIC ETC. uses the lower 8K of memory plus at least 1K of RAM for scratchpad. Because this new language was designed for games and business applications, the less frequently used scientific functions of Dartmouth BASIC are not available. It does have full string capability (up to 255 characters per string), N-dimensional arrays, variable precision arithmetic, handles assembly language routines, direct memory and I/O addressing, 27 error codes, character and line erasure editing, permits subroutine nesting, 31 commands and statements, 8 functions plus user defined functions, null control from 0 to 25 seconds, and formatted outputs.

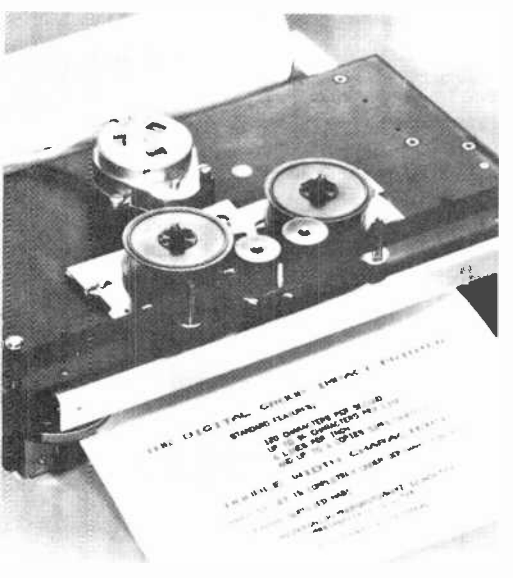
BASIC ETC is supplied on either KC audio tapes or paper tape for $25, including a 32-page detailed users manual. The manual alone sells for $6.

Tychon, Inc. (Box 242, Blacksburg, VA 24060; Tel: 703-951-9030) has developed some more interesting software for 8080-type machines. These include an Editor/Assembler tape ($25, listing $40), D-Bug tape ($10, listing $40), or a documentation package ($5) which includes all the operating instructions for the editor, assembler, and D-Bug. These programs require 4k of RAM, and are available in 1702A or 2708 ROM. Each software package includes complete documentation on its use and information about changes for different I/O formats.

The Editor and Assembler are used to prepare programs from mnemonic and symbolic statements. The D-Bug package allows changes to be made in a program through a terminal or TTY. D-Bug also has single-step, breakpoint, paper tape read/punch routines, plus 13 useful subroutines.

If you do your own thing, Tychon also makes available its 8080 Octal Code Card ($2.95) which is a slide-rule type of aid for programming and debugging 8080 software. It contains all the 8080 mnemonics and corresponding octal codes. All instructions are color-coded to indicate which flags are affected during execution. The card is 6.5 by 3 inches, and the rear side contains the ASCII code chart for all 128 characters, plus the 8080 status word and register pair codes.

Pro-Log Corp. (2411 Garden Rd, Monterey, CA 93940; Tel: 408-372-4593) is making available "The Designer's Guide to Programmed Logic—Featuring the 8080 Microprocessor" for $7.50. This 148-page book covers the applications of programmed logic and features specific uses of 8080-type processors. It is profusely illustrated with drawings and tables, and contains numerous sample programs and experiments that demonstrate programming and program/hardware integration.



Digital Group's full-size impact matrix printer.

Intel Corp. (3065 Bowers Ave., Santa Clara, CA 95051) now has an expanded user's library named Insite™ (Intel Software Index and Technology Exchange). The library contains over 200 programs for 8080 and 8008 and over 100 programs for 4040 and 4004 systems. The new Program Library Manual contains all programs with listings up to three pages long. Programs longer than three pages are described in authors' abstracts. Update packages will be published every other month. Paper tapes containing source code for each program are available for a handling fee of $15. As a bonus, new members receive five free source tapes of their own choice.

One-year membership is free to persons contributing acceptable programs, and the fee for others is $100 annually. Members receive the program library manual and update packages during the term of their membership. Key among the new library programs are two BASIC compilers for the 8080A. One executes on a paper tape system, while the other requires a disc system. Both are available for a $15 reproduction price.

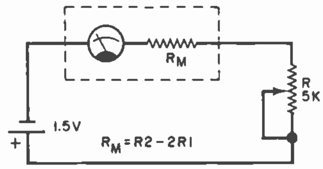
If you are looking for a new source of computer hobbyist books, try the Computer Hobbyist Book Club (5405 B Southern Comfort Blvd., Tampa, FL 33614; Tel: 813-886-9890). They have a free flier upon request.

Micro-Navigation. A unique use for a microprocessor was brought to our attention recently. Developed by R.W. Burhans (161 Grosvenor St., Athens, OH 45701; Tel: 614-594-7184 or 614-593-8207) and called the Mini-L, the system was designed for experimental study of the Loran-C, 100-kHz navigation system. The circuit generates 10-microsecond interrupt requests that are locked to the extremely accurate Loran-C signals, making it easy for microprocessor users to devise their own time-measurement software. A 26-page experimenters' manual and two pc board (no components supplied) are included in the kit. A limited number of kits are available. Contact R.W. Burhans for further data. ◇

Tips & Techniques

DETERMINING METER RESISTANCE

Most of us, at one time or another, have had to determine the internal resistance of a meter. This circuit shows one method of getting an accurate measurement. Resistor R_M



represents the internal resistance (unknown), and *R* is a 5000-ohm potentiometer (almost any one will do). The 1.5-volt battery should be a fresh flashlight cell. After breadboarding the circuit, adjust *R* for full scale deflection of the meter. Then remove *R* and measure its resistance. Record the value as *R1*. Next, put *R* back in the circuit, but this time adjust it for one-half scale deflection. Then remove *R* and measure its resistance, and record it as *R2*. Finally use the equation $R_M = R2 - 2R1$ to determine the unknown resistance.—*Ralph C. Born, Jr.*

MULTI-TURN AIR-CORE COILS

Specific values of inductance are often required by speaker crossover networks. The following formula gives the inductance of a closely wound, multi-layer, air-core coil with a rectangular winding cross-section. Accuracy is within 1 or 2%.

$L = [(2m)^2 / (b + 1.5t + r)] F^1 F^2 \times 10^{-9}$ H

where r is the mean radius of the inductor in cm, b is the axial length of the inductor in cm, t is the radial thickness of the winding in cm, and n is the total number of turns. F_1 and F_2 are correction factors which depend on the shape of the inductor. Thus,

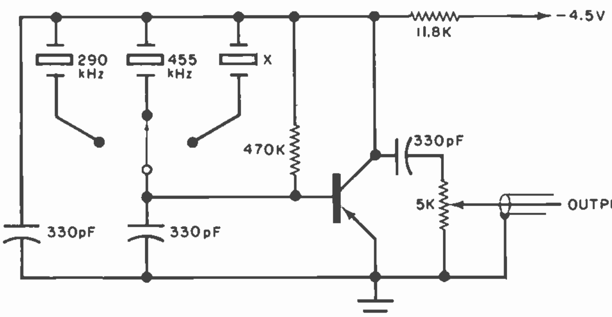
$F_1 = (10b + 13t + 2r)/(10b + 10.7t + 1.4r)$

$F_8 = 0.5 \log_{10}[100 + (14r + 7t)/(2b + 3t)]$

The equations can re rearranged to solve for any variable, of course.—*Bill Shellorne*

TWO-WAY SECOND I-F SPOTTER

This circuit was built to check 2-way mobile radios having 290- or 455-kHz intermediate frequencies. Two crystals, one at 455 kHz and the other at 290 kHz, determine the frequency of oscillation. The switch is set to select the appropriate crystal. The output level of the oscillator is adjusted by the setting of the 5000-ohm potentiometer. The output level is sufficient for use in adjusting the rig's second i-f. A third crystal can be included for a marker or other fixed frequency output.—*Bob Goff*



Operation Assist

If you need information on outdated or rare equipment—a schematic, parts list, etc.—another reader might be able to assist. Simply send a postcard to Operation Assist, POPULAR ELECTRONICS, 1 Park Ave., New York, NY 10016. For those who can help readers, please respond directly to them. They'll appreciate it. (Only those items regarding equipment not available from normal sources are published.)

Bogen Model TR 54B and R 135BT pocket pagers. Need schematic and service manual. Michael Sarembski, 53 Rutledge Rd., Scarsdale, NY 10583.

Superior Instrument Model TV-60 VOM. Hallicrafters Model S-107 shortwave receiver. Need operators manuals and schematics. Mike Kocak, 2369 Maryland Ave. #2, Cincinnati, OH 45204.

Akai Model M-7 stereo tape recorder. Service and operating manuals needed. M. J. Olah, 1100 Merriman Rd., Akron, OH 44303.

Wedgefield Model CS-506 cassette recorder. Schematic needed. H. M. Smith, 9852 Dandelion Ave., Fountain Valley, CA 92708.

Milovac Model TR-525 AM radio. Need schematic for antenna and RF stage. Norman R. Damborg, 221 So. 184 St., Seattle, WA 98148.

Stewart Warner Model R 181-A. Schematic and alignment instructions needed. Gary Bodnar, 36 Wildwood AVe., East Lansdowne, PA 19050.

International Crystal Model MO11 mobile transceiver. Schematic and/or service manual. William E. Olson, Box 245, Cedar Hill, MO 63016.

Frigistor, 32 couple module. Need source of. R. Kelsey, P. O. Box 12, Pinconning, MI 48650.

Dayton Fan and Motor Co. Model 5046 5-tube radio. Schematic needed. Cedric Walker, 520 Green St., Durham, NC 27701

Marcony Model 89 battery operated radio. Schematic needed. Mr. Alain Coulombe, Box 852, Grand Centre, Alberta Canada TOA 1TO.

Clegg Model 66 6-meter transceiver. Manual and schematic. Daniel Bodnarchuk, 138 W. Union Ave., B. Brook, NJ 08805.

RCA Model BC-342-D U.S. Army receiver. Schematic and service manual. Edward F. Maher, 489 Grand Blvd., Brentwood, NY 11717.

Hallicrafters Model SX42. Need source of tuning gear train, tuning knobs, shafts and main escutcheon. J. McClelland, 7110 Vernon, St. Louis, MO 63130.

Circosonic Model PG-8 ultrasonic cleaner. Need schematic or service manual. Bob Mooney, 72300 Varner Rd., 1000 Palms, CA 92276.

Ampro Model 758 open-reel tape deck. Toyo Model CHR-655 remote control unit. Need operation manuals or any available information. C. Leigh, Sprinkle Rd., #2, Box 25, Jackson, NJ 08627.

Hallicrafters Model R-649/UR Coast Guard radio receiver. Schematic and/or instruction manual. S. G. Blair, 1201 Palekaiko St., Pearl City, HI 96782.

Sylvania Model 145 audio oscillator. Schematic and service information needed. Brian R. Oppegaard, 127 Orchard Trace #8, Charlotte, NC 28213.

Magnatone Model 30 B music amplifier. Schematic needed. Charles E. Hopper, 9002 E. 68th St., Raytown, MO 64133.

Knight Model 83Y809-601014 604 Safari-1 CB transceiver. Schematic or service manual needed. Robert P. Hanes, 848 Mitchell St., Erie, PA 16509.

RCA Type 69-C MI-7512 distortion and noise meter. Operations manual needed. Danny Biando, P. O. Box 8653, San Jose, CA 95155.

Supreme Instruments Model 565 VTVM. Schematic, parts list and/or service manual needed. Daniel R. Lee, Rt. 1, Box 145A, Subiaco, AR 72865.

U.S. Navy Model PP-374/VRC-56 power supply. Need any available information. Mr. David O. Hansen, Broadmoor Park #B-38, 55 West Washington Ave., Yakima, WA 98908.

Precision Apparatus Model E200C signal generator and Model E400 sweep generator. Need operation and service manuals. Ken Lamarsh, 100 River Dr. S., Port Lambton, Ontario, Canada NOP 2B0.

Hammarlund Model HQ-180 receiver. Service manual and schematic needed. Joseph L. Markiewicz, 38417 Charwood Dr., Sterling, MI 48077.

Western Electric Model BC-453-B U.S. Army radio receiver. Need schematic and manual. Paul White, 1225 N. Hollydale Dr., Fullerton, CA 92631.

Friden SPS flexowriter and Model 795084 communications terminal. Need schematics and service manuals. Phil Hughes, P. O. Box 2847, Olympia, WA 98507.

Symphonic Model TPS-30 mini TV. Need source of 3-inch picture tube. Richard Grepke, RR#5, Ft. Wayne, IN 46818.

Lear Model LR-6A VHF receiver and Model RT-10E VHF transmitter. Service information needed. Kenneth R. Duncan, 930 Merrill Ave. S. W., Grand Rapids, MI 49503.

Hammarlund Model SP-600 receiver. Need schematic, service manual, alignment instruction and parts list. Jun Villanueva, 1332 26th Ave., San Francisco, CA 94122.

Stromberg-Carlson Type CCT-45106 radio receiver. Need tuning knob, schematic, dynamotor and service manual. Steve Swift, 7807-218 S.W., Apt. #54, Edmonds, WA 98020.

Symphonic Model TPS-30 TV receiver. Need source of picture tube, Ronald Benjamin, 198 N. Elmhurst Rd., Prospect Heights, IL 60070.

Tektronix Model 531 oscilloscope. Instruction manual needed. John Uscinowski, Physics Dept., Rensselaer Polytechnic Institute, Troy, NY 12181.

Raytheon Type CK 5676 tube. Need source of supply. G. Wintress, P. O. Box 373, Mt. Freedom, NJ 07970.

Lafayette 99C9037 amplifier module, 99C6034 transformer. Source or equivalent with diagrams. Gane Wong, 6103 Beatrice St., Vancouver, B.C., Canada VSP 3R3.

Dumont 304AR scope. Schematic, operator manual. Will buy or copy. Patrick Franz, Box 695, Bayview, ID 83803.

Philco 7170 am/fm generator. **Philco** 7008 visual alignment generator (for TV & FM). **Dumont** 303-A & 324 CRT's. **Accurate Instruments** 157 tube tester. Schematic, manual, or any information; also latest tube chart for 157. Robert Briggs, 124 E. Tioga St., Philadelphia, PA 19134.

Supreme Instruments 546 oscilloscope, serial number 2497. Company address or source of parts. Jack Martin, 576 Greenbriar, Fairfield, TX 75804.

Lafayette PB-50 low-band vhf tuneable public service monitor. Schematic or owner's manual. Fred F. Helmstetter, Omicron Radio Repair, 14 Lincoln Ave., Chatham, NJ 07928.

Beckman 727OR time-interval meter. Schematic. S. Goldhar, 1014 B. St., Hayward, Calif. 94541.

AC Cossor 1049 MK2 scope. **AC Cossor** 1434 preamplifier. **Serris** 22A signal generator. **Aico** 625 tube tester. Service manual, operating manual, schematic. Claude Houde, 7427 Boyer St., Montreal, P.Q., Canada H2R 2R9.

WRL Electronics Globe Chief 90-A. Schematic, owner's manual, service info. R. Begnoche, 11175 Roberts, Stockbridge, MI 49285.

Wells-Gardner RBL-3 low-frequency Navy receiver. Complete technical manual with schematics. Ron Hammock, 966 - 21st Ave, Seattle, WA 98122.

McMurdo Silver Vomax 900 VTVM. Service manual. Robert C. Pease, 340 4th Ave., Stanley, WI 54768.

Heathkit AR-3 shortwave receiver. Schematics and any other info. Stan Moore, Jr., Box 26, Thermopolis, WY 82443.

Wanlass Model MP power supply. Schematic, service info. Paul Barker, 4422A Myrtlewood Dr., Huntsville, AL 35805.

Akai VC-150 color camera, VT-150 color recorder, VTS-150 recording system. Complete info. K. Samad, Box 50072, Washington, DC 20004.

Dumont 324 scope. Manual, schematic. Deryl B. Shields, 16533 - 37th N.E., Seattle, WA 98155.

Superior Instruments TV-50 genometer, 6704 VOM. Manuals and schematics. Charles T. Allen, 6746 Parkinson Dr., Miami Lakes, FL 33014.

Sony TC-134SD cassette deck. Source of parts: screws, plastic cassette cover, set of keys. Roberto Vicentello, Quimicos 114-25, Monterrey NL, Mexico.

Precise 300 scope. Schematic and parts info on 7EP4 CRT and power transformer. M. Shen, 5 Old Mill Dr., Poughkeepsie, NY 12603.

Motorola 14P4-1. Schematic, parts list. Dean E. Cesa, 3924 Radcliffe Dr., Northbrook, IL 60062.

Heathkit AJ-30 tuner. FM multiplex adapter. Jerry W. Bolin, 16576 Sarah St., Mojave, CA 93501.

Clevite TO-01A transfilter. Source. David A. Darling, Stadium Dr. Tr. Ct. #8A, Moscow, ID 83843.

Dyna Quik 675 mutual transconductance tester. Need card 41, or copy of numbers punched out on card 41. Anton S. Melka, RFD Rt. 1, Box 55, Butte, MT 59701.

Sonora Model C radio. Info and schematics. A.C. Crimmel, 11210 Rannoch La., Louisville, KY 40243.

Fisher Research Skipper marine-band transceiver. Schematic and any other info. Paul Prescott, Allen Rd., Brookfield, CT 06804.

Tele-Instrument 2113 TV signal generator. Schematic, manual, any info. Charles King, 6 Willow Ct., Cromwell, CT 06416.

General Electric 250 portable radio, uses 2-V plug-in wet storage battery. Source for battery, schematic, plastic dial, service manual, or set to cannibalize. Ole G. Morby, 15 Sturges Commons, Westport, CT 06880.

Aiwa TP-728 cassette recorder. Schematic. Paul Montor, 1040 N. Martin Rd., Janesville, WI 53545.

Links 1905-2G vhf transceiver. Schematic. Clinton E. Hartsfield, R.B. Electronics, 3009 Alta Mira Dr., Richmond, CA 94806.

Johnson Viking 6NZ converter. Instruction manual, schematic. Arthur Gillman, 14 Pine St., Princeton, NJ 08540.

Longines Symphonette AM/FM/cassette recorder. Instruction manual, schematic. Roy O. Kroeger, 104 N. Michigan, Roswell, NM 88201.

Autovox OC-401 shortwave mobile converter. Source. G.E. Ferguson, 3905 Clayton Rd., Apt. 14, Concord, CA 94521.

Rondine B-12H turntable. Schematic and any other info. Anthony A. Gihrdanella, Box 31, Star Rte., Chatham, NY 12037.

DeVry IC/QEB-10 sound movie projector. IC/QPB-ID manual and parts. Fabian Bourge, Box 626, Vinton, LA 70668.

Philco 41-245 receiver. Schematic, source of XXL tubes, info on last date of manufacture. R. Culbertson, 601 Cornplanter Ave., Oil City, PA 96301.

Kent 6620 musical-instrument amplifier. Schematic and any other info. David Baughman, 155 East Main St., Newark, OH 43053.

Elmac Trans-Citer AF-67 amateur transmitter. Harvey Wells Bandmaster R9-A receiver. Schematics, manuals. Paul Prescott, Allen Rd., Brookfield, CT 06804.

Beckman 797 decimal counting unit for Beckman 8379AR frequency counter and timer. Source. Danny Baindo, Box 8653, San Jose, CA 95155.

ICS meter, kit TK28653MS. Assembly manual. A.D. Lane, Box 1203, Framingham, MA 01701.

Advent 300 receiver. Schematic. R.K. Brush, 1965 E. 3375 South, Salt Lake City, UT 84106.

Knight-Kit KG-389 fuzz box. Schematic, parts list, layout. Joseph Viau, 84 Friendly Rd., Cranston, RI 02910.

General Electric 260 radio. Schematic, source of 1LC6, 1LN5, 1LN4, 3Q5(GT/G) tubes. Roberto Leal, Kelley's Tr. Ct. #5 Lot 8, Alexandria, LA 71301.

Globe 65-220 Globemaster CB radio. Power transformer. **Motorola** FM TRU-5V taxi radio. Components Q-8528, PA 8548; schematics, source, plugs, etc. Tom Ash, Route 7, Box 105, Mortantown, OH 26505.

Waterman S-14-B Pocketscope. Schematic, manual. George Kabroth, 218 N. Arch St., Mechanicsburg, PA 17055.

Hammarlund HQ-129-X shortwave receiver. Hookup diagrams for antenna and any other info. Paul Ziemba, 3616 Greenbriar, Midland, MI 48640.

Paco V-70. Schematic, calibration instructions (with layout of adjustment controls.) Will buy or copy. Howard Adams, 209 W. Shadywood Dr., Midwest City, OK 73110.

Loewe Optacord 403 tape recorder, serial number 09014.

Operation manual and/or schematic, parts list. Stefan Pawlikowski, Apt. 8, 2 Grace St., Wawa, Ontario, Canada POS 1K0.

Hickok 18 signal generator. Schematic, service and operation manuals, and any other info. D. Engen, 2804 Spencerville Rd., Burtonsville, MD 20730.

Hallicrafter SRO receiver. Calibrated dial scale (083-000982), trim plate panel (007-000793). John Allanson, 515 Pleasant St., New Glasgow, Nova Scotia, Canada B2H 3A1.

Concord 994 tape recorder. Schematic. Marion B. Harrelson, 6400 Liberty Rd., Baltimore, MD 21207.

Hallicrafter SX-43 receiver. Wiring diagram. Speaker impedance info. Kenneth A. Sheets, 38 Mayfield Hts., Beaver Falls, PA 15010.

Dumont 304A scope. Operating and maintenance manuals. Edward Medovich, 14B Old Hickory Dr., Apt 2A, Albany NY 12204.

Superior 77 VTVOM. Source of 9006 tubes, or substitute. George Snell, Lakeside Rd., Waterport, NY 14571.

Eldico SSB-100MIL (MARS) exciter/transmitter. Instruction manual and/or schematics. Harold Screven, 90 Jamie St., Islip Terr., NY 11752.

Jackson TVG-2 TV signal generator, serial 4158. Operation manual, schematic. J.D. Nasmith, 311 Bunting Rd., Unit #9, St. Catharines, Ontario, Canada L2M 3Y4.

Hallicrafter SX-28 Super Skyrider receiver. Need wire-wound, metal-cased resistor for voltage divider. Fred Berrier, 1126 Phillips Ave., Knox, TN 37920.

U.S. Govt. R-392/URR receiver, 500 kHz to 32 MHz. Voltage requirements, operator manual, source of power supply and speakers. Cande Palermo, 83 William St., Yonkers, NY 10701.

Columbian Aqua-Probe CB303 depth finder. Schematic, parts list. Buy or pay for copy. Kermit D. Lloid, Rte. 1, Box 1360 Natchitoches, LA 71457.

Heathkit GW-10 CB transceiver, circa 1961. Tube-location diagram. John D. Harmon, 22107 Blackburn, St. Clair Shores, MI 48080.

Beckman 727OR interval counter. Schematic. S. Goldhor, 1014 B. St., Hayward, CA 94541.

Unisonic 817L desk calculator. Schematic, parts list. Joseph F. Schussler, 20 Dorett Dr., Wappingers Falls, NY 12590.

Motorola CP-30FN tape recorder. Schematic. Michael Persic, 18021 Karen Dr., Encino, CA 91316.

American Concertone 505 reel-to-reel tape recorder. Schematic, parts list, or any info. Duncan Crawford, 160 E. Holmes Hall, E. Lansing, MI 48824.

Grundig-Majestic 7000, circa 1957. Schematic. A. Chandler, 2707 38th St. W., Bradenton, FL 33505.

Sears 570 AM/FM-stereo receiver. Schematic, operating manual., Ned Black, RFD #1, S. Windham, ME 04082.

HFE T4214A oscillograph, made in England. Schematics, any other info. Barry Fuerst, 218 Flournoy St., Oak Park, IL 60304.

Eico 753 transceiver. Schematic, operation and assembly manual, parts list. Leland D. Walton, 1189 El Sendero, Salt Lake City, UT 84117.

Hammarlund SP600/X21, serial 20414. Schematic and/or service manual. Pollak Gabriel, POB 9029, Beer-Sheva, Israel.

Philco 37-630 AM/SW receiver, cabinet code 122-type T, circa 1936-37. Need glass dial-cover and ring. Also need Philco High Efficiency Aerial supplied with receiver. F. Keith Haywood, Box 537, Angier, NC 27501.

Stromberg-Carlson 863 receiver. Schematic and any other info. Randy Baker, 2 Beckfoot Dr., Dartmouth, Nova Scotia, Canada B2Y 4C8.

Majestic 62A table radio. **General Electric** GE-93 radio. Schematics. R. Smith, 3188 Rumsey, Ann Arbor, MI 48105.

Stephens Tru-Sonic multi-cellular midrange horn speaker system. Replacement P-M driver needed. Frank J. Burris, 35640 Ave. F, Ycaipa, CA 92399.

Viking 85 tape deck. Operating and service manuals. William Lee, 4 Mallard Dr., Center Moriches, NY 11934.

Milovac CT711 TV, serial F00318. Need service info. Clinton Chamberlin, 10 Old North Rd., Walden Park, Mountaintop, PA 18707.

U.S. Govt. APX-6/RT-279 transponder. Schematic, service and operating manuals, also data on conversion to 1215 MHz needed. Nick Raeside, Wildwood Cres., RR #3, B.C., Canada V0S 1E0.

Hammarlund HQ-170A amateur receiver. Any and all information, also antenna coils for any band. Will buy HQ-170A for cannibalization. Wayne Stratton, 11426 Stewart Lane, Silver Spring, MD 20904.

Leitch 21-56 Meter-Matic VTVM. Schematic or tube layout needed. Noor S. Khalsa, 242 Oxford St., Hartford, CT 06105.

U.S. Govt./Landers, Frary & CLark AN/URM-105 multimeter; S/N 2749; Order No. 4930-PP-61. Schematic, operations manual. Ray Miller, Box 181, Antioch, CA 94509.

General Electric A-87 radio. Schematics and/or service manuals. Mel Peterson, 778 Richland RD., Yuba City, CA 95991.

Wire recorder, wanted to borrow or rent for transcribing old recordings. C.R. Opela, 203 Asbury, Evanston, IL 60202.

Jackson TVG-2 signal generator. Schematic and calibration data. **B&K** 500 tube tester. Most recent charts, calibration data, schematic. Mike Miller, 20 Hemlock Ave., Sonoma, CA 95476.

Hammarlund HQ-170 receiver. Schematic, service and operation manuals. Douglas Coverdale, RR #3, Box 77A, Nobbsville, IN 46060.

U.S. Army Signal Corps TS175C/U frequency meter. Need operating manual. J. Allen Call, 1876 E. 2990 S., Salt Lake City, UT 84106.

Premier reverb. Schematic, tube types. Steve Andrusyshyn, RD #3, Diemer's Hill, Pottsville, PA 17901.

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Avg. Ship. Wt. 6 ozs.

Buy 10 BARREL KITS AND CHOOSE THE 11TH KIT Free

KIT #237 LED DISPLAY MOLEX PINS — 200 for $1.98
Pins 3/8" long, 1/10" spacing. For displays, keyboards. Wt. 4 ozs. 6E3594

BARREL KIT #229 MULTI-DIGIT READOUTS — 10 for $1.98
Barrels of 8's, 6's, & 9-digit readouts, some with driver chips. Wut a buy! Untested. No. 6E3628

BARREL KIT #225 SOUND TRIGGERS — 3 for $1.98 6 ozs.
"Hand clap" sensitizes crystal mike amplifier, triggers SCR. Cat. No. 6E3625

BARREL KIT #221 IC SOCKETS — 8 for $1.98
Mfr unloads! Four 14-pin, four 18-pin. Solder tail, lo-profile. No. 6E3621

MIXED READOUTS KIT #219 — 15 for $1.98
Barrels of untested .17", .3", .5", 7-segs. Like FND-357, 500, 503, MAN-3's. Wut a buy! No. 6E3619

BARREL KIT #217 LAMPS! — 25 for $1.98
Distributor unloads barrels of asstd bulbs, pop'l'r voltages to 24V. Screw & bayonet. Wt. 4 ozs. No. 6E3561

BARREL KIT #211 LO-PROFILE TO-5 — 50 for $1.98
NPN power transistors, mostly good. Bvceo 40V, Ic 2A, Hfe 30-100. Up to 260 MHZ! Like RCA 2N5189. Wt. 12 oz. No. 6E3551

BARREL KIT #210 GLOWIN' PANELS — 3 for $1.98
4" x 1" panels that glow blue-green with 110VAC. Use for nite lites, indicators, etc. Cat. No. 6E3550

BARREL KIT #205 MINI BLOCK CAPACITORS — 50 for $1.98
Unbelievable! Worth $50. High precision submini caps for all applications. Wt. 3 ozs. Cat. 6E3528

BARREL KIT #203 CALCULATOR KEYBOARDS — 10 for $1.98
It's true! 20-key, 4 function keyboards at ridiculous give-away. Wt. 12 ozs. Cat. No. 6E3524

KIT #202 PLUGS, SOCKETS — 100 for $1.98
Distributor unloads. Includes AC, DC, RF, audio, 4-9 pin, all kinds. Wt. 1 lb. Cat No. 6E3527

BARREL KIT #201 6V INDICATORS w/leads — 15 for $1.98
Test lamp manufacturer dumps inventory! Worth 69¢ ea. Like grain-o-wheat. Cat. No. 6E3526

BARREL KIT #200 9 DIGIT READOUT MODULES — 5 for $1.98
with calculator driver chips beneath epoxy. Cat. No. 6E3515

BARREL KIT #198 TRANSISTORS & DARLINGTONS — 50 for $1.98
Motorola dumps 1,000,000 TO-220 in barrels. NPNs & PNPs. Cat. No. 6E3533

BARREL KIT #194 10-AMP INLINE BRIDGE RECTIFIERS — 20 for $1.98
Asstd voltage. We can't test 'em. No. 6E3475

BARREL KIT #192 NYLON GEARS — 40 for $1.98
Wide variety of sizes 1" to 3" gears for the mechanical gear train hobbyists. Wt. 10 ozs. No. 6E3427

BARREL KIT #191 CARBOFILM RESISTORS — 800* for $1.98
*1/2 pound, approx. 1/8, 1/4 watters. Asst values. Unmarked. Cat. No. 6E3445

BARREL KIT #188 400 Parts — $1.98
Includes resistors, caps, transformers, rectifiers, diodes, etc. for p.c. work. Preformed, dumped into barrels by factories. 100%. Cat. No. 6E3401

BARREL KIT #186 KEYBOARD CHIPS — 10 for $1.98
Truthfully we can't test em. MM5740's, keyboard encoder chips. No. 6E3414

BARREL KIT #184 1/4-WATT METAL FILM — 150 for $1.98
100% metal film resistors. Long leads. 6E3413

BARREL KIT #182 JUMBO RED LEDS — 15 for $1.98
100% material, user cancellation from factory dumps, 3V 10 mils. For 100's of projects, red lens. Cat. No. 6E3369

BARREL KIT #181 MICRO ZENERS — 100 for $1.98
1-Watt, tiny, 100% material, from 2V to 30V. Axial leads. No shorts, no opens. DO-7 & micro epoxy units. Cat. No. 6E3368

BARREL KIT #163 MINI TRIM POTS — 30 for $1.98 1 oz.
Asst. values 100 to 1 meg. What a buy. Single turn. 1/4 W, Wt. 6 oz. 6E3345

BARREL KIT #161 "POP" PLASTIC TRANSISTORS — 25 for $1.98
2N3904's with some 2N3906's of 100% material. TO-92. Preformed. Cat. No. 6E3343 1 oz.

BARREL KIT #160 V. REGULATORS — 10 for $1.98
No. 6E3330
LM309KC TO-3 V.R.'s barreled. Bot by the pound.

BARREL KIT #159 MODULAR SWITCHES — 25 for $1.98
Centralab switches. TV-makers excess. Dpdt, 6pdt, etc. Brand new. Cat. No. 6E3150

BARREL KIT #158 MAGNIFIED MAN-3's — 20 for $1.98
MAN-3, 7-seg readout, with built-on magnifier. Factory discontinued line. 100% material. Cat. No. 6E3325 1 oz.

BARREL KIT #154 CLOCK CHIPS — 20 for $1.98
We gathered an assortment of clock chip, alarm, calendar, beepers, who knows, all mixed. Cat. No. 6E3308

BARREL KIT #149 ROCKER SWITCHES — 12 for $1.98
No. 6E 3302

BARREL KIT #145 MINI TRANSFORMER — 15 for $1.98
outputs, interstage and audio. Only 1" sq. Wt. 2 lbs. 6E3294

BARREL KIT #144 RCA PHONO PLUGS — 40 for $1.98
1,000,000 RCA phono plugs for this one. You hi-fi-ers know wut they are . . . 100% material. 6E 3293

BARREL KIT #138 PANEL SWITCHES — 30 for $1.98
Did you hear of OAK? Another eqpt maker barrelled all types of rotaries, electric, slides, etc. 6E3268

BARREL KIT #135 MICRO MINI LAMPS — 20 for $1.98 1 oz.
Imagine! Micro size (1/4 x 1/8) with wire leads. 3 to 5 VDC, 40 mils. 6E3259

BARREL KIT #128 MINI DIP ICS — 100 for $1.98
Large mfgr dumped 100's of lbs into barrels. Includes 741s, LM-380-8, 703, 567, 555, 558—but who knows? Wt. 1 lb. 6E3245

BARREL KIT #127 AXIAL ELECTROS — 40 for $1.98
Asst. capacities and voltages. Cat. No. 6E3227

BARREL KIT #126 UPRIGHT ELECTROS — 40 for $1.98
1mf to 300mf in mixture of voltages. 100% marked 'n good. 6E3226

BARREL KIT #115 MOLEX SOCKETS — 200 for $1.98 100% good Cat.No. 6E3144
Calculator maker dump! We gut a zillion of 'em.

BARREL KIT #112 MICRO MINI LEDS — 40 for $1.98
All the tiny leds, axial, upright of Monsanto, Litronix, variety of colors. Yield 60% or better. 6E3138

BARREL KIT #109 TERMINAL STRIPS — 100 for $1.98
Wide asst. of terminal strip connectors, from 1 contact up. Strip manufacturers barrel dump is your gain. Wt. 1 lb. Cat.No 6E 3136

BARREL KIT #104 SLIDE VOLUME CONTROLS — 10 for $1.98
Cat.No. 6E3057

BARREL KIT #101 RESISTOR SPECIAL — 200 for $1.98
Includes: 1/8, 1/4, 1/2, 1, 2-watters, carbon. 8 oz. 100% good. 6E3054

BARREL KIT #99 PHOTO ELECTRIC CELLS — 10 for $1.98
Asst. GE types, CDS types. Mixed by factory. Big job for us to separate. 100% good. Cat.No. 6E3052

BARREL KIT #93 HALF WATTERS — 200 for $1.98
Resistor factory tried to fool us by mixing 100% color-coded resistors in barrel. But value is there. 4 oz. 6E3046 Untested

BARREL KIT #92 3 AMP EPOXY RECTIFIERS Untested — 100 for $1.98
Cosmetic rejects, electrically fine business! You check 'em, it's not for us. Asst. voltages. 6E3204

BARREL #91 SILVER MICAS — 100 for $1.98
Axial, red case, variety of physical sizes & values. Cat.No. 6E3018

BARREL KIT #88 LITRONICS LED READOUTS — 10 for $1.98
747's, 727's, singles, triples, etc. .33 to 0.6. Bot from factory, all mixed; have fun! No. 6E2861

BARREL KIT #87 NATIONAL IC BONANZA — 100 for $1.98
Types 8000, 7400 series, DTLs, ROMs, registers, clock & calc. chips, linears, etc. Cat.No. 6E 2860 Untested.

BARREL KIT #86 HOBBY LEDS — 40 for $1.98 Untested
747's, 727's, singles, triples, etc. .33 to 0.6. Bot from factory, all mixed; have fun! 6E2859

BARREL KIT #83 LM-340T VOLT REG — 15 for $1.98
Factory rejected them for length of leads. May include 5, 6, 8, 12, 15, 18, 24 volts. Power tab. Cat. 6E2635

BARREL KIT #81 SUBMINI RESISTORS — 200 for $1.98
PC, upright type, color coded, 1/8 watt. Asst values. Came to us in a barrel. Cat.No 6E2746 100% good.

BARREL KIT #76 1-WATT ZENERS — 100 for $1.98
Factory same as 400-mw's. Never-to-see-again offer. 6, 8, 10, 12, 15V, under glass. Double plug. Cat.No. 6E2741 Untested.

BARREL KIT #73 TRANSISTOR ELECTROS — 50 for $1.98
We don't wish to separate wide asst voltages & values up to 300 mf. Cat. 6E2747

BARREL KIT #71 CAPACITOR SPECIAL — 100 pcs. $1.98
micas, moldeds, plastics, ceramics, discs, etc. Nifty 100% good Cat.No 6E2738

BARREL KIT #68 2 WATTERS — 100 for $1.98 100% good.
Suppliers throw 'em in the barrel. It's a li'l gold mine. All marked. Cat.No. 6E2735

BARREL KIT #65 MIXED READOUTS — 10 for $1.98
Factory returns — such numbers as MAN-4's, MAN-7's, MAN-3's, 11 barrels & no time to separate. Cat.No. 6E2733 Untested.

BARREL KIT #61 POLYSTYRENE CAPS — 100 for $1.98
Finest caps made. As a gamble we bought 10 barrels from factory, mixed values all good. Cat.No. 6E2729

BARREL KIT #58 SLIDE SWITCHES — 30 for $1.98
All shapes, sizes, spst, dpdt, momentaries, etc. Tremendous shop pak for 100's of switching projects. Cat.No 6E2726 100% good

BARREL KIT #56 POWERS! POWERS! — 100 for $1.98 Cat. 6E2724
Large distributor cleaned house. Barrels of power resistors 3 to 7 watts.

BARREL KIT #54 8 DIGIT READOUTS — 10 for $1.98
Bargain of a lifetime! All we got was 1 barrel — the "blisdor digit" types. Multiplexed. Cat. No. 6E2722

BARREL KIT #40 PNP HIGH-POWER TRANSISTORS — 20 for $1.98
Popular germanium TO-3 case. 6E2618 100% good

BARREL KIT #39 2N3055 HOBBY TRANSISTORS — 15 for $1.98
Fallouts of the famous 2N3055. 6E2617 100%

THE Hottest Savings OF THE YEAR! 1¢ SALE

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Order by Cat. No. 6E1981 & Type No. – Sale 2 For

Type No.	Sale	2 For
☐ SN7400N	$0.16	$0.17
☐ SN7401N	.16	.17
☐ SN7402N	.16	.17
☐ SN7403N	.16	.17
☐ SN7404N	.16	.17
☐ SN7405N	.18	.19
☐ SN7406N	.20	.21
☐ SN7407N	.25	.26
☐ SN7409N	.18	.19
☐ SN7410N	.16	.17
☐ SN7411N	.25	.26
☐ SN7413N	.45	.46
☐ SN7417N	.32	.33
☐ SN7420N	.16	.17
☐ SN7421N	.29	.30
☐ SN7423N	.35	.36
☐ SN7425N	.27	.28
☐ SN7430N	.16	.17
☐ SN7437N	.26	.27
☐ SN7438N	.26	.27
☐ SN7440N	.16	.17
☐ SN7441N	.84	.85
☐ SN7442N	.53	.54
☐ SN7445N	.69	.70
☐ SN7446N	.79	.80
☐ SN7447N	.79	.80
☐ SN7448N	.76	.77
☐ SN7450N	.16	.17
☐ SN7451N	.16	.17
☐ SN7454N	.16	.17
☐ SN7464N	.16	.17
☐ SN7470N	.45	.46
☐ SN7472N	.34	.35
☐ SN7473N	.36	.37
☐ SN3474N	.31	.32
☐ SN7475N	.49	.50
☐ SN7476N	.31	.32
☐ SN7478N	.79	.80
☐ SN7483N	.69	.70
☐ SN7489N	1.95	1.96
☐ SN7490N	.44	.45
☐ SN7491N	.73	.74
☐ SN7492N	.47	.48
☐ SN7493N	.47	.48
☐ SN7494N	.78	.79
☐ SN7495N	.78	.79
☐ SN7496N	.72	.73
☐ SN74100N	.98	.99
☐ SN74106N	.65	.66
☐ SN74107N	.33	.34
☐ SN74112N	.65	.66
☐ SN74113N	.65	.66
☐ SN74114N	.65	.66
☐ SN74121N	.38	.39
☐ SN74123N	.59	.60
☐ SN74125N	.59	.60
☐ SN74126N	1.00	1.01
☐ SN74132N	.59	.60
☐ SN74141N	.88	.89
☐ SN74145N	.69	.70
☐ SN74148N	1.29	1.30
☐ SN74150N	.99	1.00
☐ SN74151N	.70	.71
☐ SN74153N	.65	.66
☐ SN74154N	1.03	1.04
☐ SN74155N	.70	.71
☐ SN74157N	.70	.71
☐ SN74158N	.85	.86
☐ SN74160N	.88	.89
☐ SN74161N	.88	.89
☐ SN74164N	.79	.80
☐ SN74165N	.99	1.00
☐ SN74173N	1.39	1.40
☐ SN74174N	.97	.98
☐ SN74175N	.89	.90
☐ SN74176N	.79	.80
☐ SN74177N	.79	.80
☐ SN74181N	2.05	2.06
☐ SN74184N	1.75	1.76
☐ SN74185N	1.75	1.76
☐ SN74190N	1.15	1.16
☐ SN74191N	1.05	1.06
☐ SN74192N	.87	.88
☐ SN74193N	.83	.84
☐ SN74195N	.73	.74
☐ SN74196N	.88	.89
☐ SN74198N	1.49	1.50
☐ SN74199N	1.49	1.50
☐ SN74200N	3.95	3.96
☐ SN74251N	1.09	1.10
☐ SN74284N	5.95	5.96
☐ SN74285N	5.95	5.96

BARREL KIT #37 1 AMP "BULLETT" RECTIFIERS Untested — 100 for $1.98
Famous style, asstd. voltages, silicon, axial includes all types of voltages to 1KV. Cat.No. 6E2615

BARREL KIT #36 GERMANIUM DIODES Untested — 200 for $1.98
Cat.No. 6E2614
Famous maker, popular item. Never grows old.

BARREL KIT #35 NEON LAMPS — 30 for $1.98 100% good.
Famous NE-2's. All prime, but factory made millions and barrel'ed 'em. Your advantage Cat.No 6E2613

BARREL KIT #31 METALLIC RESISTORS — 100 for $1.98
Made mostly by Corning, the finest resistor made. Mostly 1/2 watters, 1% to 5% tol. & a barrel of values. Cat. No. 6E2609

BARREL KIT #30 PREFORMED RESISTORS — 200 for $1.98
We got barrels of 1/4 and 1/2" watters for pc use. 100: 1/4, 100 1/2" watters. No. 6E2608 100% good

BARREL KIT #27 PREFORMED DISCS — 150 for $1.98
Hi-Fi mfr's shelf inventory but he dumped 'em in barrels. Preformed, for PC use, Mixed values too! 6E2605

KIT #26 PLASTIC TRANSISTORS — 100 for $1.98 Untested.
Type TO-92 (TO-18), all manufacturers, variety of 2N #'s. Cat.No 6E2604

BARREL KIT #25 METAL CAN TRANSISTORS — 100 for $1.98
Includes TO-5, TO-1, TO-18, etc., assorted 2N numbers, unmarked etc. Cat.No 6E2603 Untested.

BARREL KIT #20 LONG LEAD DISCS — 100 for $1.98
"auction sale". Prime, marked only. Long leads. Cat.No 6E2598 100% good

BARREL KIT #19 DIPPED MYLARS — 60 for $1.98
Finest capacitors made, shiny finish. Imagine factory dumping 'em in barrels. Cat.No. 6E2597 100% good

BARREL KIT #17 LINEAR & 7400 DIPS — 100 for $1.98 Untested
Marked and unmarked, internal numbers of raw factory stock. Cat.No 6E2431

BARREL KIT #15 MOSFET TRANSISTORS — 60 for $1.98
All 4 leaders TO-18 case, includes UHF transistors too! Cat.No. 6E2429

BARREL KIT #14 PRECISION RESISTORS — 200 for $1.98
Marked and unmarked 1/4, 1/2, 2 watts. No 6E2428

BARREL KIT #11 POWER TAB TRANSISTORS — 40 for $1.98
NPN, plastic TO220 type. Assorted 2N numbers. No. 6E2425 Untested.

BARREL KIT #10 ROMS-REGISTERS — 75 for $1.98 Untested
2's to 40 pin devices, marked, internal factory numbers, etc. Cat.No 6E2424

BARREL KIT #8 SUBMINIATURE IF TRANSFORMERS — 75 for $1.98
Amazing. Includes 455kcs, osc, antenna, who knows? Cat.No. 6E2422 100% good

BARREL KIT #7 VOLUME CONTROL — 30 for $1.98 100% good
Singles, duals, variety of values, styles, big ones — small ones. Cat.No. 6E2421

BARREL KIT #5 SCRS, TRIACS, QUADRACS — 40 for $1.98
Raw factory stock! All the 10 amp types. Cat.No. 6E2419 Untested.

BARREL KIT #4 "4000" RECTIFIERS — 100 for $1.98 Untested.
1N4000 series. May include 25, 50, 100, 200, 400, 600, 800 and 1000 volters. 6E2417

BARREL KIT #3 1N4148/914 SWITCHING DIODES — 100 for $1.98
Imagine famous switching diodes at these prices! Cat.No. 6E2418 Untested.

BARREL KIT #2 LINEAR OP AMPS, DIPS — 75 for $1.98 Untested
May include 709's, 741's, 703's, 560 series, 566 includes 6E2416

BARREL KIT #1 SN7400 DIP IC'S — 75 for $1.98
Marked 14 and/or with 16 pin dips, may include gates, registers, flip flops, counters. 6E2415 Untest

Terms: Add postage Rated: net 30
Phone: Wakefield, Mass. (617) 245-3829
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CRYSTALS

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Part #	Frequency	Case/Style	Price
CY1A	1.000 MHz	HC33/U	$5.95
CY2A	2.000 MHz	HC33/U	$5.95
CY3A	4.000 MHz	HC18/U	$4.95
CY7A	5.000 MHz	HC18/U	$4.95
CY12A	10.000 MHz	HC18/U	$4.95
CY14A	14.31818 MHz	HC18U	$4.95
CY19A	18.000 MHz	HC18/U	$4.95
CY22A	20.000 MHz	HC18/U	$4.95
CY30B	32.000 MHz	HC18/U	$4.95

XR-2206KB Kit $27.00 **Special** XR-2206KA Kit $17.00

EXAR

WAVEFORM GENERATORS
XR-205 $8.40
XR-2206CP 4.49
XR-2207CP 3.85

TIMERS
XR-555CP [illegible]
XR-320P 1.55
XR-556CP 1.85
XR-2556CP 3.20
XR-2240CP 3.25

MISCELLANEOUS
XR-2211CP $6.70
XR-4136 .99
XR-1468 3.85
XR-1488 5.80
XR-1489 4.80
XR-2208 5.20

STEREO DECODERS
XR-1310CP $3.20
XR-1310EP 3.20
XR-1800P 3.20
XR-2567 2.99

PHASE LOCKED LOOPS
XR-210 5.20
XR-215 6.60
XR-567CP 1.95
XR-567CT 1.70

CONNECTORS

PRINTED CIRCUIT EDGE-CARD

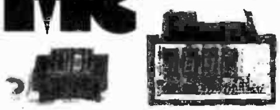
156 Spacing-Tin-Double Read-Out
Bifurcated Contacts — Fits .054 to .070 P.C. Cards

15/30	PINS (Solder Eyelet)	$1.95
18/36	PINS (Solder Eyelet)	$2.49
22/44	PINS (Solder Eyelet)	$2.95
50/100 (.100 Spacing)	PINS (Solder Eyelet)	$6.95

25 PIN-D SUBMINATURE

DB25P	PLUG	$3.25
DB25S	SOCKET	$4.95

IMC 3½ DIGIT DVM KIT



This 0-2 VDC .05 per cent digital voltmeter features the Motorola 3½ digit DVM chip set. It has a 4 LED display and operates from a single +5V power supply. The unit is provided complete with an injection molded black plastic case complete with Bezel. An optional power supply is available which fits into the same case as the 0-2V DVM allowing 117 VAC operation.

A. 0-2V DVM with Case $49.95
B. 5V Power Supply $14.95

VECTOR WIRING PENCIL

Vector Wiring Pencil P173 consists of a hand held featherweight (under one ounce) tool which is used to guide and wrap insulated wire fed off a self-contained replaceable bobbin onto component leads or terminals installed on pre-punched P Pattern Vectorbord. Connections between the wrapped wire and component leads, pads or terminals are made by soldering. Complete with 250 FT of ted wire **SPECIAL $7.95**

REPLACEMENT WIRE — BOBBINS FOR WIRING PENCIL

W36-3-A-Pkg 3	250 ft	36 AWG GREEN	$2.40
W36-3-B-Pkg 3	250 ft	36 AWG RED	$2.40
W36-3-C-Pkg 3	250 ft	36 AWG CLEAR	$2.40
W36-3-D-Pkg 3	250 ft	36 AWG BLUE	$2.40

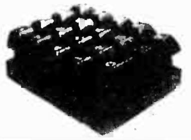
1/16 VECTOR BOARD

	0.1" Hole Spacing Part No.	P-Pattern L	W	Price 1	2-Up
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 062XXXP	4.50	17.00	3.69	3.32
EPOXY GLASS	64P44 062	4.50	6.50	2.07	1.86
	84P44 062	4.50	8.50	2.56	2.31
	169P44 062	4.50	17.00	5.04	4.53
	169P84 062	8.50	17.00	9.23	8.26
EPOXY GLASS COPPER CLAD	169P44 062C1	4.50	17.00	6.80	6.12

HEAT SINKS

205-CB	Beryllium Copper Heat Sink with Black Finish for TO-5	$ .25
291-.36H	Aluminum Heat Sink for TO-220 Transistors & Regulators	$ .25
680-.75A	Black Anodized Aluminum	$1.60

HEXADECIMAL ENCODER 19-KEY PAD



- 1 – D
- ABCDEF
- Return Key
- Optional Key (Period)
- — Key

$10.95 each

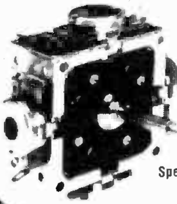
63 KEY KEYBOARD

This keyboard features 63 unencoded SPST keys unattached to any kind of P.C.B. A very solid molded plastic base suits most applications.

$19.95

HD0165 16 LINE TO FOUR BIT PARALLEL KEYBOARD ENCODER $7.95

JOYSTICK



These joysticks feature four * potentiometers, that vary resistance proportional to the angle of the stick. Sturdy metal construction with plastics components only at the movable joint. Perfect for electronic games and instrumentation.

Special ***5K Pots $4.95**
***100K Pots $7.95**

MICROPROCESSOR COMPONENTS

8080A	CPU	$19.95	8228	System Controller - Bus Driver	$10.95
8212	8 Bit Input/Output	4.95	MC6800L	8 Bit MPU	35.00
8214	Priority Interrupt Control	15.95	MC6820L	Periph. Interface Adapter	15.00
8216	Bi-Directional Bus Driver	6.95	MC6810AP1	128 x 8 Static RAM	6.00
8224	Clock Generator/Driver	10.95	MC6830L7	1024 x 8 Bit ROM	18.00
CDP1802	- with user manual	39.95	Z80	CPU	49.95

CPU'S

8080	Super 8008	24.95
8080A	Super 8008	19.95

SR'S

2504	1024 Dynamic	$3.95
2518	Hex 32 Bit	7.00
2519	Hex 40 Bit	4.00
2524	512 Dynamic	2.49
2525	1024 Dynamic	6.00
2527	Dual 256 Bit	3.95
2529	Dual 512 Bit	3.00
2532	Quad 80 Bit	3.95
2533	1024 Static	Special 5.95
3341	Fifo	6.95
74LS670	16 x 4 Reg	3.95

UART'S

AY 5-1013	30K Baud	$5.95

ROM'S

2513	Char. Gen.	$9.95
2516	Char. Gen.	10.95

RAM'S

1101	256 x 1	Static	$1.49
2101	256 x 4	Static	5.95
2102	1024 x 1	Static	1.75
2107 5280	4096 x 1	Dynamic	4.95
2111	256 x 4	Static	6.95
7489	16 x 4	Static	2.49
8101	256 x 4	Static	6.95
8111	256 x 4	Static	6.95
8599	16 x 4	Static	3.49
91L02	1024 x 1	Static	2.25
74200	256 x 1	Static	6.95
93421	256 x 1	Static	2.95
MM5262	2K x 1	Dynamic	2 for 1.00

PROMS

1702A	2048	Famos	$9.95
5203	2048	Famos	14.95
82S23	32 x 8	Open C	5.00
82S123	32 x 8	Tristate	5.00
74S287	1024	Static	7.95
3601	256 x 4	Fast	3.95
2708	8K	Eprom	29.95
6301-1	1024	Tri-State Bipolar	3.49
6330-1	256	Open Collector Bipolar	2.95
6331-1	256	Tri-State Bipolar	2.95

SPECIAL REQUESTED ITEMS

AY-3-8500-1	$19.95						
MC3061P	3.50	CD4508	6.75	82S115	25.00	3341	6.95
MC4016P (74416)	7.50	CD4515	6.50	5841	9.95	9368	3.95
MC14583	3.50	CD4520	2.70	MK50240	17.50	MC14C8L7	9.95
MC14562	14.50	MCM6571	17.50	11C90	19.95	LD110/LD111	25.00 set
CD4059	9.95	MCM6574	17.50	DS0026CH	3.75	AY-5-9100	17.50 ea
CD4070	.95	MCM6575	17.50	TIL308	10.50	95H90	13.95

PARATRONICS

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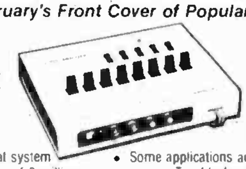
Featured on February's Front Cover of Popular Electronics

Logic Analyzer Kit



MODEL 100A
$189.00/Kit

- Analyzes any type of digital system
- Checks data rates in excess of 8 million words per second
- Trouble shoot TTL, CMOS, DTL, RTL, Schottky and MOS families
- Displays 16 logic states up to 8 digits wide
- See ones and zeros displayed on your CRT, octal or hexadecimal format
- Tests circuits under actual operating conditions
- Easy to assemble — comes with step-by-step construction manual which includes 80 pages on logic analyzer operation.

- Some applications are
  - — Troubleshooting microprocessor address, instruction, and data flow
  - — Examine contents of ROMS
  - — Tracing operation of control logic
  - — Checking counter and shift register operation
  - — Monitoring I/O sequences
  - — Verifying proper system operations during testing

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Introductory Offer — all 6 books (worth $49.95)
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(6" long X 4" wide)

Other CS Proto Boards

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PB101 - 5.8" x 4.5"	29.95
PB102 - 7" x 4.5"	39.95
PB103 - 9" x 6"	59.95
PB104 - 9.5" x 8"	79.95
PB203 - 9.75 x 6½ x 2¾	75.00
PB203A - 9.75 x 6½ x 2¾ (includes power supply)	120.00

Logic Monitor $84.95
for DTL, HTL, TTL or CMOS Devices

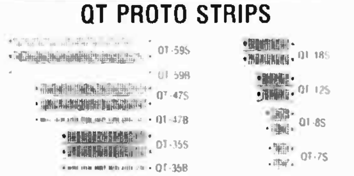
PROTO CLIPS

14 PIN	$4.50
16 PIN	4.75
24 PIN	8.50

DESIGN MATES

DM1 - Circuit Designer 54.95
DM2 - Function Generator 69.95
DM3 - RC Bridge 59.95

QT PROTO STRIPS



QT type	# holes	price
QT-59S	590	12.50
QT-59B	bus strip	2.50
QT-47S	470	10.00
QT-47B	bus strip	2.25
QT-35S	350	8.50
QT-35B	bus strip	2.00
QT-18S	180	4.75
QT-12S	120	3.75
QT-8S	80	3.25
QT-7S	70	3.00

Experimentor 300	$9.95
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- Doze Button
- 100% Solid State
- Large Red Led Display (.8" high)
- AM PM indicator
- Seconds display at touch of button
- Power failure indicator
- One year factory warranty

C-8211
Woodgrain Case
$19.95

DIGITAL AUTO INSTRUMENT

SEVEN DIFFERENT INSTRUMENTS!

MEETS OR EXCEEDS ORIGINAL AUTOMOTIVE SPECS.

Please specify which one of the seven models you want when ordering - these do not all come in one unit. Each model must be bought separately.

1. TACHOMETER 0-9900 RPM 4, 6 or 8 Cyclinders
2. WATER TEMP. 100-250° F
3. FUEL LEVEL Percentage Low Fuel Indicator
4. SPEEDOMETER* 0-99 MPH
5. OIL PRESSURE 0-80 PSI
6. OIL TEMP 200-350° F
7. BATTERY MONITOR ±1 Volts From 11-15 VDC

BRIGHT YELLOW ORANGE .3" LED DISPLAY!

Kit includes case, bracket and all componets — complete. Nothing else to buy! 12 Volt NEG GRD.
DIMENSIONS 4½ x 4 x 2 **KIT: $49.95**
* Add $10.00 for required speed transducer **ASSEMBLED: $59.95**

DIGITAL STOPWATCH

- Bright 6 Digit LED Display
- Times to 59 minutes 59.59 seconds
- Crystal Controlled Time Base
- Three Stopwatches in One Times Single Event — Split & Taylor
- Size 4.5" x 2.15" x .90" (4½ ounces)
- Uses 3 Penlite Cells

Kit — $39.95
Assembled — $49.95
Heavy Duty Carry Case $5.95

Stop Watch Chip Only (7205) $19.95

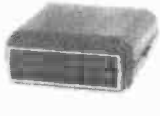
ELECTRONIC 'PENDULUM' CLOCK

- Swing Pendulum
- .7" Hours and Minutes Display
- 12 or 24 Hour Mode
- Time Set Push Buttons
- Alarm Feature

Kit-unfinished (case unassembled) $59.95
Assembled-stained (case assembled) $69.95

QUARTZ DIGITAL AUTO CLOCK OR ELAPSED TIMER!

Elapsed Timer: Hrs, Mins and Secs
12 or 24 Hr Capacity
Simple Reset - Start Pushbutton Control



Complete kit includes mounting bracket, case and all components, nothing else to buy. Features MM5314 chip. Large .4" LED's. Accuracy better than ± min. per mo. internal battery backup. 12 volt non-polar operation.

DIMENSIONS 4½ x 4 x 2"
12 or 24 HOUR MODE

Kit: $29.95
Assembled: $39.95

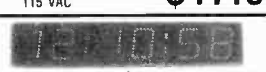
CASE ONLY (includes hardware, mounting bracket and bezel) **$6.50**

JE700 CLOCK

12 or 24 Hour
115 VAC

The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6" x 2½" x 1". It utilizes a MAN72 high brightness readout, and the MM5314 clock chip.

$17.95



DIGITAL CLOCK KIT — 3½ INCH DIGITS

4 DIGIT KIT $49.95 **4 DIGIT ASSEMBLED $59.95**
6 DIGIT KIT $69.95 **6 DIGIT ASSEMBLED $79.95**

This clock features big 3½" high digits for viewing in offices, auditoriums, etc. Each digit is formed by 31 bright 0.2" LED's. The clock operates from 117 VAC, has either 12 or 24 hr. operation. The 6 digit version is 27" x 3½" x 1½" and the 4 digit is 18" x 3½" x 1½". Kits come complete with all components, case and transformer.

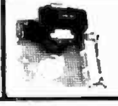
Specify 12 or 24 Hour When Ordering

JE803 PROBE

The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols: (HI) - 1 (LOW) - 0 (PULSE) - P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.

$9.95 Per Kit
printed circuit board

T²L 5V 1A Supply



This is a standard TTL power supply using the well known LM309K regulator IC to provide a solid 1 AMP of current at 5 volts. We try to make things easy for you by providing everything you need in one package, including the hardware for only **$9.95 Per Kit**

7400N TTL

SN7400N	16	SN7459A	25		
SN7401N	16	SN7460N	22	SN74154N	1.00
SN7402N	21	SN7470N	45	SN74155N	99
SN7403N	16	SN7472N	39	SN74156N	99
SN7404N	18	SN7473N	37	SN74157N	99
SN7405N	21	SN7474N	32	SN74160N	1.25
SN7406N	20	SN7475N	50	SN74161N	99
SN7407N	29	SN7476N	32	SN74163N	99
SN7408N	25	SN7479N	5.00	SN74164N	1.10
SN7409N	25	SN7480N	50	SN74165N	1.10
SN7410N	18	SN7482N	98	SN74166N	1.25
SN7411N	30	SN7483N	70	SN74167N	5.58
SN7412N	33	SN7485N	89	SN74170N	2.10
SN7413N	45	SN7486N	39	SN74172N	8.95
SN7414N	70	SN7488N	3.50	SN74173N	1.50
SN7416N	35	SN7489N	2.49	SN74174N	1.25
SN7417N	35	SN7490N	45	SN74175N	99
SN7420N	21	SN7491N	75	SN74176N	90
SN7421N	33	SN7492N	49	SN74177N	90
SN7422N	49	SN7493N	49	SN74180N	99
SN7423N	37	SN7494N	79	SN74181N	2.49
SN7425N	29	SN7495N	79	SN74182N	95
SN7426N	29	SN7496N	89	SN74184N	1.95
SN7427N	37	SN7497N	4.00	SN74185N	2.20
SN7429N	42	SN74100N	1.00	SN74186N	15.00
SN7430N	26	SN74107N	39	SN74187N	6.00
SN7432N	31	SN74121N	39	SN74188N	3.95
SN7437N	27	SN74122N	39	SN74190N	1.19
SN7438N	27	SN74123N	50	SN74191N	1.25
SN7439N	25	SN74125N	60	SN74192N	89
SN7440N	15	SN74126N	60	SN74193N	89
SN7441N	89	SN74132N	1.09	SN74194N	1.25
SN7442N	59	SN74136N	95	SN74195N	75
SN7443N	75	SN74141N	1.15	SN74196N	1.25
SN7444N	75	SN74142N	4.00	SN74197N	75
SN7445N	75	SN74143N	4.50	SN74198N	1.75
SN7446N	81	SN74144N	4.50	SN74199N	1.75
SN7447N	69	SN74145N	1.15	SN74200N	5.59
SN7448N	79	SN74147N	2.35	SN74279N	90
SN7450N	26	SN74148N	2.00	SN74251N	1.79
SN7451N	27	SN74150N	1.00	SN74284N	6.00
SN7453N	27	SN74151N	79	SN74285N	6.00
SN7454N	20	SN74153N	89	SN74367N	75

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20% Discount for 100 Combined 7400's

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CD4001	25			74C10N	65
CD4002	25	CD4035	1.85	74C20N	65
CD4006	2.50	CD4040	2.75	74C30N	65
CD4007	25	CD4042	1.90	74C42N	2.15
CD4009	59	CD4044	1.50	74C73N	1.50
CD4010	59	CD4046	2.51	74C74N	1.15
CD4011	25	CD4047	2.75	74C90N	3.00
CD4012	25	CD4049	79	74C95N	2.00
CD4013	47	CD4050	79	74C107N	1.25
CD4016	56	CD4051	2.95	74C151	2.90
CD4017	1.35	CD4053	2.95	74C154	3.00
CD4019	55	CD4060	3.25	74C157	2.15
CD4020	1.49	CD4066	1.75	74C160	3.25
CD4022	1.25	CD4069	45	74C161	3.25
CD4023	25	CD4071	45	74C163	3.00
CD4024	1.50	CD4081	45	74C164	3.25
CD4025	25	CD4511	2.50	74C173	2.60
CD4027	69	CD4518	2.50	74C192	2.75
CD4028	1.65	MC14566	3.00	74C195	2.75
CD4029	2.90	74C00N	39	MC4044	4.50
CD4030	65	74C02N	55	MC14016	50

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LM300H	80			LM1351N	1.65
LM301H	35			LM1414N	1.75
LM301CN	35			LM1458C	65
LM302H	75	LM370N	1.15	LM1496N	95
LM304H	1.00	LM373N	3.25	LM1556V	1.85
LM305H	95	LM377N	4.00	LM2111N	1.95
LM307CN	35	LM380N	1.39	LM2901N	2.95
LM308H	1.00	LM380CN	1.05	LM3065N	69
LM308CN	1.00	LM381N	1.79	LM3900N	55
LM309H	1.10	LM382N	1.79	LM3905N	60
LM309K	99	NE501K	8.00	LM3909	1.25
LM310CN	1.15	NE510A	6.00	LM5556N	1.85
LM311H	90	NE531H	3.00	MC5558V	1.00
LM311N	90	NE536T	6.00	LM7525N	90
LM318CN	1.50	NE540L	6.00	LM7535N	1.25
LM319N	1.30	NE550N	79	8038B	4.95
LM320K-5	1.35	NE555V	39	LM75450	49
LM320K-5.2	1.35	NE560B	5.00	75451CN	39
LM320K-12	1.35	NE561B	5.00	75452CN	39
LM320K-15	1.35	NE562B	5.00	75453CN	39
LM320T-5	1.75	NE565H	1.25	75454CN	39
LM320T-5.2	1.75	NE565N	1.25	75491CN	79
LM320T-8	1.75	NE566CN	1.25	75492CN	89
LM320T-12	1.75	NE567H	1.95	75494CN	89
LM320T-15	1.75	NE567V	1.50	RCA LINEAR	
LM320T-18	1.75	LM703CN	45	CA3013	2.15
LM320T-24	1.75	LM709H	29	CA3023	2.55
LM323K-5	9.95	LM709N	29	CA3035	2.48
LM324N	1.80	LM710N	79	CA3039	1.35
LM339N	1.70	LM711N	39	CA3046	1.30
LM340K-5	1.95	LM723H	55	CA3059	3.25
LM340K-6	1.95	LM723N	55	CA3060	3.25
LM340K-8	1.95	LM733N	1.00	CA3080	85
LM340K-12	1.95	LM739N	1.00	CA3081	2.00
LM340K-15	1.95	LM741CH	35	CA3082	2.00
LM340K-18	1.95	LM741CN	35	CA3083	1.60
LM340K-24	1.95	LM741-14N	39	CA3086	85
LM340T-5	1.75	LM747H	79	CA3089	3.75
LM340T-6	1.75	LM747N	79	CA3091	10.20
LM340T-8	1.75	LM748H	39	CA3102	2.95
LM340T-12	1.75	LM748N	39	CA3123	2.15
LM340T-15	1.75	LM1303N	90	CA3130	1.39
LM340T-18	1.75	LM1304N	1.19	CA3140	1.25
LM340T-24	1.75	LM1305N	1.40	CA3600	1.75
LM350N	1.00	LM1307N	85	RC4194	5.95
LM351CN	65	LM1310N	2.95	RC4195	3.25

74LS00 TTL

[illegible]	[illegible]			74LS139	1.35
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	74LS109	[illegible]	74LS175	1.35

CLOCK CHIPS

MM5309	6 Digit BCD Outputs Reset Pin	[illegible]
MM5311	6 Digit BCD Outputs 12 or 24 Hour	4.95
MM5312	4 Digit BCD Outputs 1 PPS Output	4.95
MM5314	6 Digit 12 or 24 Hour 50 or 60 Hz	4.95
MM5316	4 Digit Alarm 1 PPS Output	6.95
MM5318	Video Clock Chip For Use With (MM5841 $9.95)	9.95
CT7001	6 Digit Calendar Alarm 12 or 24 Hour	5.95

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7400 P... & Description of 5400/7400 ICS $2.95
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...ar Pin out & Functional Description $2.95
ALL THREE HANDBOOKS $6.95

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T236 Yellow w/bracelet $34.95
LED

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125 dia						190 dia		
XC209	Red	10/$1				XC111	Red	10/$1
XC209	Green	4/$1				XC111	Green	4/$1
XC209	Orange	4/$1				XC111	Yellow	4/$1
XC209	Yellow	4/$1				XC111	Orange	4/$1
200 dia			185 dia			200 dia		
XC22	Red	10/$1	XC526	Red	5/$1	XC556	Red	10/$1
XC22	Green	4/$1	XC526	Green	4/$1	XC556	Green	5/$1
XC22	Yellow	4/$1	XC526	Yellow	4/$1	XC556	Yellow	5/$1
XC22	Orange	4/$1	XC526	Orange	4/$1	XC556	Orange	5/$1
SSL-22	RT	4/$1	XC526	Clear	4/$1	XC556	Clear	5/$1

085 dia MV50 Red 6/$1
INFRA RED LED 5/$1.00

SPECIAL * — XC556 Red 100/$8.00 1000/$60.00 — SPECIAL *

DISPLAY LEDS

TYPE	POLARITY	HT		TYPE	POLARITY	HT	
MAN 1	Common Anode	270	2.95	MAN 3640	Common Cathode-orange	300	[illegible]
MAN 2	5 x 7 Dot Matrix	300	4.95	MAN 4710	Common Anode-Red	400	95
MAN 3	Common Cathode	125	1.00	DL701	Common Anode-red	300	[illegible]
MAN 4	Common Cathode	187	1.95	DL704	Common Cathode	300	[illegible]
MAN 7G	Common Anode	300	1.25	DL707	Common Anode	300	[illegible]
MAN 7G	Common Anode-green	300	1.95	MAN [illegible]	Common Anode Red	400	99
MAN 7Y	Common Anode-yellow	300	1.95	DL747	Common Anode	600	1.50
MAN 52	Common Anode-green	300	99	DL 749	Common Anode	600	[illegible]
MAN 64	Common Anode-red	400	99	DL 750	Common Cathode	600	2.49
MAN 72	Common Cathode	300	1.50	DL 338	Common Cathode	110	50
MAN 82	Common Anode-yellow	300	99	FND70	Common Cathode	250	75
MAN 84	Common Cathode-yellow	300	99	FND503	Common Cathode	500	1.00
MAN 3620	Common Anode-orange	300	1.75	FND507	Common Anode	500	1.00

ATARI GAME BOARDS

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BOARD A — [illegible] x 16 $6.95 ea.
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ONLY 500 EA AVAILABLE

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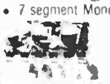
ONLY 500 EA AVAILABLE

HP 5082-7300 Multi-Digit Series

- ⅛" Ht. • Common Cathode • Dip Package
- 3 to 5 volts @ 5 mils per segment
- 7 segment Monolithic • Red Display



2 Digit	$ .79
3 Digit	.89
4 Digit	.99
5 Digit	1.19

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$ .17	16	15	24 pin	$ .38	37	36
14 pin	20	19	18	28 pin	45	44	43
16 pin	22	21	20	36 pin	60	59	58
18 pin	29	28	27	40 pin	63	62	61
22 pin	37	36	35				

SOLDERTAIL STANDARD (TIN)

	1-24	25-49	50-100		1-24	25-49	50-100
14 pin	$ .27	25	24	28 pin	$ .99	90	81
16 pin	30	27	25	36 pin	1.39	1.26	1.15
18 pin	35	32	30	40 pin	1.59	1.45	1.30
24 pin	49	45	42				

SOLDERTAIL STANDARD (GOLD)

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$ .30	27	24	24 pin	$ .70	63	57
14 pin	35	32	29	28 pin	1.10	1.00	90
16 pin	38	35	32	36 pin	1.75	1.40	1.26
18 pin	52	[illegible]	[illegible]	40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100		1-24	25-49	50-100
10 pin	$ .45	41	37	24 pin	$1.05	95	85
14 pin	39	38	37	28 pin	1.40	1.25	1.10
16 pin	43	42	41	36 pin	1.59	1.45	1.30
18 pin	75	68	62	40 pin	1.75	1.55	1.40

Plastic Push Button Switch

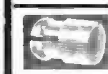
- 18 AWG Solid Wire - 5" Long
- .50 (wide) X .60 (high) ⅜-27 Thread
- 8 AMP @ 14 Volt - 1 AMP @ 110 Volt

		1-9	10-Up
J-188-1	Push On-Push Off	59	49
J-188-2	Normally Open	59	49
J-188-3	Normally Closed	59	49

MINATURE TOGGLE SWITCH

JMT-221	DPDT	on/off on	$1.95
JMT-223	DPDT	on/none on	$1.75
JMT-121	SPDT	on/off/on	$1.50
JMT-123	SPDT	on/none on	$1.25

CLIPLITE 8/$1.49



LED MOUNTING SYSTEM
use with XC556 LEDS
Specify Colors — Red Green Amber Yellow

DIP SWITCHES

SPST Slide Action

#206-8 8 pin dip 4 switch unit $1.75 ea.
#206 14 pin dip 7 switch unit $1.95 ea.
#206 16 pin dip 8 switch unit $2.25 ea.

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

ASST. 1	5 ea	10 OHM 27 OHM	12 OHM 33 OHM	15 OHM 39 OHM	18 OHM 47 OHM	22 OHM 56 OHM	1/4 WATT 5%	50 PCS.
ASST. 2	5 ea	68 OHM 180 OHM	82 OHM 220 OHM	100 OHM 270 OHM	120 OHM 330 OHM	150 OHM 390 OHM	1/4 WATT 5%	50 PCS.
ASST. 3	5 ea	470 OHM 1.2K	560 OHM 1.5K	680 OHM 1.8K	820 OHM 2.2K	1K 2.7K	1/4 WATT 5%	50 PCS.
ASST. 4	5 ea	3.3K 8.2K	3.9K 10K	4.7K 12K	5.6K 15K	6.8K 18K	1/4 WATT 5%	50 PCS
ASST. 5	5 ea	22K 56K	27K 68K	33K 82K	39K 100K	47K 120K	1/4 WATT 5%	50 PCS
ASST. 6	5 ea	150K 390K	180K 470K	220K 560K	270K 680K	330K 820K	1/4 WATT 5%	50 PCS
ASST. 7	5 ea.	1M 2.7M	1.2M 3.3M	1.5M 3.9M	1.8M 4.7M	2.2M 5.6M	1/4 WATT 5%	50 PCS

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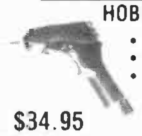
HOBBY-WRAP TOOL-BW-630



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- Complete with built-in bit and sleeve

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WRAP • STRIP • UNWRAP

- Tool for 30 AWG Wire
- Roll of 50 Ft. White or Blue 30 AWG Wire
- 50 pcs. each 1", 2", 3" & 4" lengths — pre-stripped wire

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WIRE WRAP TOOL WSU-30

WRAP • STRIP • UNWRAP - $5.95

WIRE WRAP WIRE — 30 AWG

25 ft. min. $1.25 50 ft. $1.95 100 ft. $2.95 1000 ft. $15.00
SPECIFY COLOR — White - Yellow - Red - Green - Blue - Black

CUTTER CRIMPER TOOL (CS-8)

- Plier Nose (serrated-jaw)
- Scissors Action Cutting
- 6 Bolt Cutters (4-40, 5-40, 6-32, 8-32, 10-32, 10-24)
- Crimp Stations (7mm Auto — 22-20 to 12-10 elect.)
- "Up-Front" Wire Cutting
- Scissors Action Stripping (No. 22-20 to No. 10)
- Crimp Stations — insulated (22-20 to 12-10 elect.)

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TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
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1N751A	5.1	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N3600	50	200m	6/1.00
1N754	6.8	400m	4/1.00	1N4148	75	10m	15/1.00
1N959	8.2	400m	8/1.00	1N4154	35	10m	12/1.00
1N965B	15	400m	4/1.00	1N4305	75	25m	20/1.00
1N5232	5.6	500m	28	1N4734	5.6	1w	28
1N5234	6.2	500m	28	1N4735	6.2	1w	28
1N5235	6.8	500m	28	1N4736	6.8	1w	28
1N5236	7.5	500m	28	1N4738	8.2	1w	28
1N456	25	40m	6/1.00	1N4742	12	1w	28
1N458	150	7m	6/1.00	1N4744	15	1w	28
1N485A	180	10m	6/1.00	1N1183	50 PIV	35 AMP	1.60
1N4001	50 PIV	1 AMP	12/1.00	1N1184	100 PIV	35 AMP	1.70
1N4002	100 PIV	1 AMP	12/1.00	1N1185	150 PIV	35 AMP	1.50
1N4003	200 PIV	1 AMP	12/1.00	1N1186	200 PIV	35 AMP	1.80
1N4004	400 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR	$1.95
C38M	35A @ 200V	SCR	1.95
2N2328	1.6A @ 200V	SCR	50
MDA 980-1	12A @ 50V	FW BRIDGE REC	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC	1.95

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2N2222	5/$1.00	PN3569	4/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3704	5/$1.00	2N4403	4/$1.00
2N2369A	4/$1.00	2N3705	5/$1.00	2N4409	5/$1.00
2N2484	4/$1.00	2N3706	5/$1.00	2N5086	4/$1.00
2N2906	4/$1.00	2N3707	5/$1.00	2N5087	4/$1.00
2N2907	5/$1.00	2N3711	5/$1.00	2N5088	4/$1.00
2N2925	5/$1.00	2N3724	$ .65	2N5089	4/$1.00
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2N3055	$ .89	2N3903	5/$1.00	2N5138	5/$1.00
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MJE2955	$1.25	2N3905	4/$1.00	2N5209	5/$1.00
2N3392	5/$1.00	2N3906	4/$1.00	2N5951	5/$1.00
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		2N4014	3/$1.00	2N6028	$2.00
		2N4123	10/$1.00		

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50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10 pf	05	04	03	001µF	05	04	035
22 pf	05	04	03	0047µF	05	04	035
47 pf	05	04	03	01µF	05	04	035
100 pf	05	04	03	022µF	06	05	04
220 pf	05	04	03	047µF	06	05	04
470 pf	05	04	035	1µF	12	09	075

100 VOLT MYLAR FILM CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
001mf	12	10	07	022mf	13	11	08
0022	12	10	07	047mf	21	17	13
0047mf	12	10	07	1mf	27	23	17
01mf	12	10	07	22mf	33	27	22

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
1 35V	28	23	17	1.5 35V	30	26	21
15 35V	28	23	17	2.2 25V	31	27	22
22 35V	28	23	17	3.3 25V	31	27	22
33 35V	28	23	17	4.7 25V	32	28	23
47 35V	28	23	17	6.8 25V	36	31	25
68 35V	28	23	17	10 25V	40	35	29
1.0 35V	28	23	17	15 25V	63	50	40

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
47 50V	15	13	10	47 25V	15	13	10
1.0 50V	16	14	11	47 50V	16	14	11
3.3 50V	15	13	10	1.0 16V	15	13	10
4.7 25V	16	14	12	1.0 25V	16	14	11
10 25V	15	13	10	1.0 50V	16	14	11
10 50V	16	14	12	4.7 16V	15	13	10
22 25V	17	15	12	4.7 25V	15	13	10
22 50V	24	20	18	4.7 50V	16	14	11
47 25V	19	17	15	10 16V	14	12	09
47 50V	25	21	19	10 25V	15	13	10
100 25V	24	20	18	10 50V	16	14	12
100 50V	35	30	28	47 50V	24	21	19
220 25V	32	28	25	100 16V	19	15	14
220 50V	45	41	38	100 25V	24	20	18
470 25V	33	29	27	100 50V	35	30	28
1000 16V	55	50	45	220 16V	23	17	16
2200 16V	70	62	55	470 25V	31	28	26

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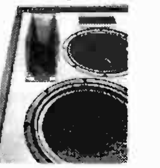

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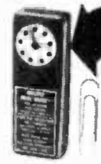

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7414N	.63
7420N	.17
7422N	1.39
7430N	.20
7433N	39
7438N	25
7440N	.17
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7445N	.85
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7447N	.60
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74109N	85
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74132N	1.25
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74151N	.75
74154N	1.10
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74157N	.95
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74163N	1.35
74174N	1.19
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74193N	.85
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74LS05N	.34
74LS08N	.28
74LS10N	.28
74LS13N	.67
74LS14N	1.30
74LS20N	.28
74LS22N	.34
74LS28N	.41
74LS30N	.28
74LS33N	.39
74LS38N	.39
74LS74N	.46
74LS75N	.65
74LS90N	1.10
74LS93N	1.10
74LS95N	1.89
74LS107N	.52
74LS112N	.52
74LS113N	52
74LS132N	1.15
74LS136N	.59
74LS151N	1.60
74LS155N	1.50
74LS157N	1.40
74LS162N	2.05
74LS163N	2.05
74LS174N	1.85
74LS190N	2.60
74LS221N	1.95
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74S74	68

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LM339N	1.55
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LM340K-8	1.60
LM340K-12	1.60
LM340K-15	1.60
LM340K-24	1.60
LM340T-5	1.50
LM340T-8	1.70
LM340T-12	1.70
LM340T-15	1.70
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LM340T-24	1.70
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CD4028	1.50
CD4029	1.70
CD4030	.42
CD4035	2.00
CD4040	1.35
CD4042	1.50
CD4043	2.00
CD4044	2.00
CD4046	2.90
CD4049	.62
CD4050	.55
CD4051	2.10
CD4060	2.10
CD4066	.85
CD4068	.25
CD4069	.40
CD4070	.40
CD4071	.40
CD4072	.40
CD4073	.40
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CD4078	.40
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CD4527	4.75
CD4528	1.50
CD4553	5.75
CD4566	2.25
CD4583	4.50
CD4585	2.10
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74C04	.33
74C10	.28
74C14	2.10
74C20	.28
74C30	.28
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21078	8.00
2111-1	7.00
2112-2	7.90
2513B	8.75
21L02-1	2.50
MM5058	2.20
MM5060	3.20
MM5262	.90
MM5320	5.95
MM5330	9.75
PD411D-3	7.00
PD411D-4	8.00

CLOCKS

MM5309	3.90
MM5311	3.60
MM5312	4.80
MM5313	3.60
MM5314	3.90
MM5315	4.00
MM5316	5.00
MM5318	8.95
MM5369	2.10
MM5371N	5.50
MM5841	10.80
CT7001	5.80
MM5375AA/N	3.90
MM5375AB/N	4.90
7205	16.50
DS0026CN	3.75
DS0056CN	3.75
MM53104	3.75

MICROPROCESSOR

8080 with data	19.00
8080A with data	23.50
8212	4.50
8224	8.50
8228	8.50
CDP1802CD	29.50
CDP1802D	35.00

KEYBOARDS
63 Key Keyboard $19.95 with HD0165 encoder add 6.95

IC SOCKETS
Solder Tin Low Profile

PIN	1 UP	PIN	1 UP
8	.15	24	.35
14	.18	28	.43
16	.20	36	.58
18	.27	40	.61
22	.35		

UART/FIFO

AY5-1013	6.20
3341	6.95

Data Access Arrangement Kit. Instr. Incl. 10.00

IC Test Clips	1	10
Red	.50	[illegible]
Black	.50	[illegible]

PROM

1702A	7.95
N82S23	3.25
N82S123	4.00
N82S126	4.85
N82S129	4.85
2708	29.50
DM8577	2.90

SPECIAL PRODUCTS

LM1812N Ultrasonic Transceiver	7.50
LM3909N LED Flasher Oscillator	.69
Switches Mom. Pushbutton	.50
On off on toggle	1.35
On none on toggle	1.15
Encoder HD0165-5	7.50
3 Digit Universal Counter Board Kit Operates 5-18 Volt DC to 5 MHz typ. .125" LED display	10.50

RESISTORS ¼ watt 5%

10 per type	.05
25 per type	.03
100 per type	.025
1000 per type	.02

LEDS

Red TO18	.15
Green TO18	.20
Orange TO18	.20
Yellow TO18	.20
Jumbo Red	.20
Jumbo Green	.25
Jumbo Yellow	.25
Jumbo Orange	.25
Cliplite LED mounting Clips (specify red, amber, green, yellow, clear)	8/$1.25

TRANSFORMERS

12 Volt 300 ma transformer	1.25
12.6V CT 600 ma	3.75
12V 250 ma wall plug	2.95
12V CT 250 ma wall plug	3.50

Keyer 8043 14.50 complete with spec and socket

SCMP Keyboard Kit $95.00
SCMP Kit $99.00

CRYSTALS

1 MHz	4.50	6.5536 MHz	4.50
2 MHz	4.50	1.8432 MHz	4.50
4 MHz	4.25	2.0100 MHz	3.50
5 MHz	4.25	2.097152 MHz	7.75
10 MHz	4.25	2.4576 MHz	7.50
18 MHz	3.90	3.2768 MHz	7.50
20 MHz	3.90	5.0688 MHz	4.50
32 MHz	3.90	5.185 MHz	4.50
32768 Hz	4.00	5.7143 MHz	4.50
3.5795 MHz	1.50	18.432 MHz	4.50
		22.1184 MHz	4.50

DISPLAY LEDS

MAN1	CA	.270	2.90
MAN3	CC	.125	.39
MAN6640 Dual	CC	.500	3.50
MAN72	CA	.300	1.50
MAN74	CC	.300	1.50
DL704	CC	.300	1.25
DL707	CA	.300	1.50
DL727	CA	.500	2.55
DL747	CA	.600	2.25
FND359	CC	.357	.95
FND503	CC	.500	1.00
FND510	CA	.500	1.00
FND800	CC	.800	2.20
FND807	CA	.800	2.20
DG8 Fluorescent			1.75
DG10 Fluorescent			1.75
5 digit 14 pin display			2.50
NSN33M 3 digit 8 pin			.39
NSN69 9 digit display			.60
7520 Clairex photocells			.25
TIL311 Hex			9.00

TV GAME CHIPS

MM57100 6 Games Chip	$15.00
MM53104 Clock Driver	3.75
LM1889 Modulator	3.00
GI AY38500-1	19.50

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2K EPROM Kit	135.00
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MA1010A, C or E .50"	11.95
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Includes everything except case. 2-PC boards. 6-.50" LED Displays. 5314 clock chip, transformer, all components and full instructions. **Same clock kit with .80" displays. $22.75**

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Fully wired and tested. **$75.00**
Add $10.00 for beautiful plexiglass case.

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MM5369	Divider	2.10	1.40
2102-1	500 NS 1K RAM	1.80	1.30
PD411-3	150 NS 4K RAM	8.00	5.75
Momentary Pushbutton Switch		.50	.29

Other parts also available

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50" clock module, crystal time base. Operates from 9V battery. Complete with case and instructions. Excellent for airplane, darkroom, car, etc.

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8080A CPU, Crystal Clock, I/O Buffers, RAM and PROM. D/A—A/D converter. PROM Programmer. Memory expandable. Complete documentation Incl. assembly instruct., programming etc. **$195.00**

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RCA CMOS Microcomputer
CDP1802 CD $29.50 Users Manual $7.50
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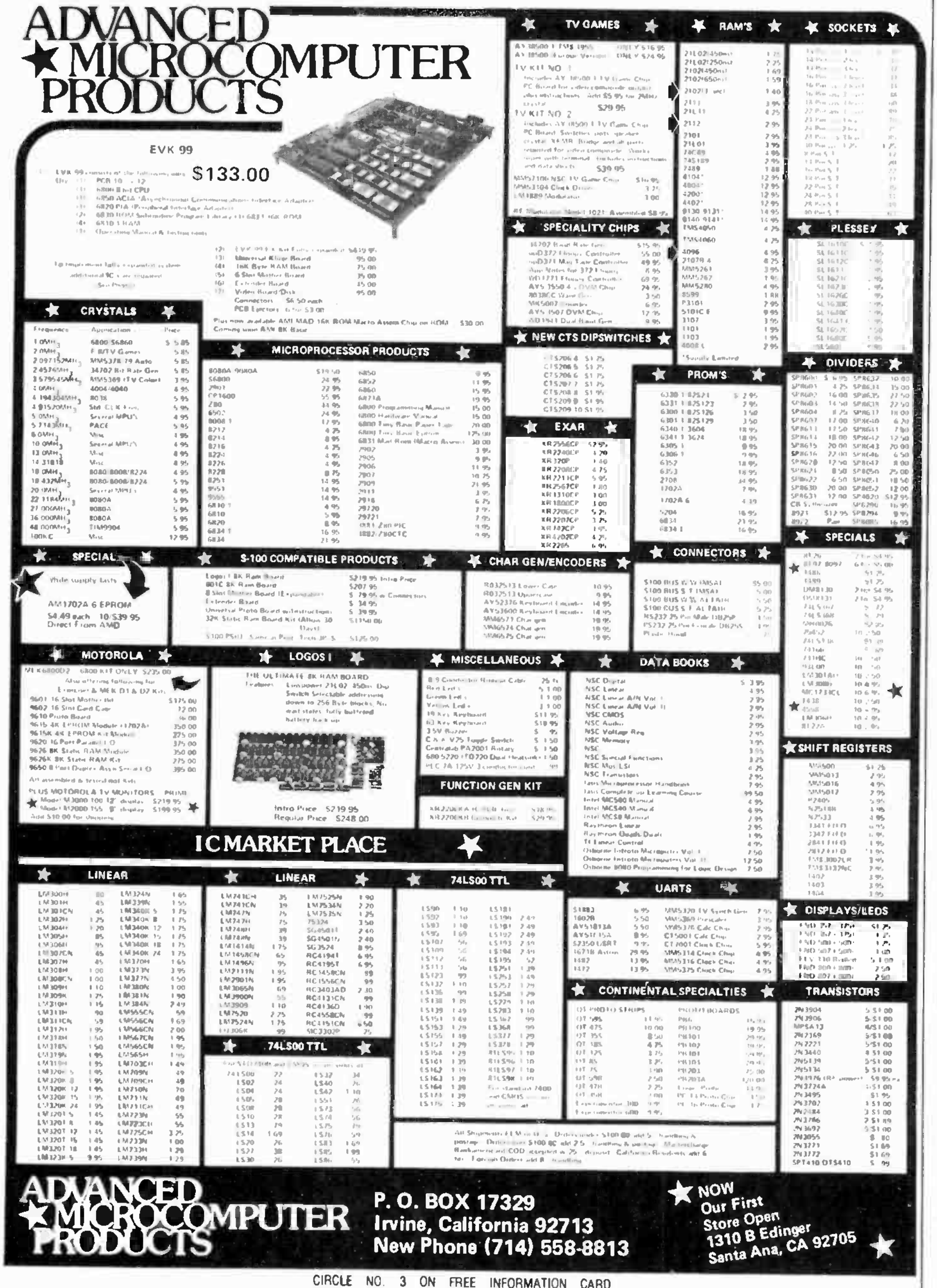

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74LS11	.28
74LS12	.28
74LS13	.47
74LS14	1.02
74LS15	.28
74LS20	.28
74LS21	.28
74LS22	.28
74LS26	.33
74LS27	.33
74LS30	.28
74LS32	.33
74LS37	.33
74LS38	.33
74LS40	.28
74LS42	.67
74LS47	.79
74LS48	.77
74LS51	.28
74LS54	.28
75LS55	.28
74LS73	.39
74LS74	.39
74LS75	.53
74LS76	.39
74LS78	.39
74LS83	.79
74LS86	.39
74LS90	.57
74LS92	.57
74LS93	.57
74LS107	.39
74LS109	.39
74LS112	.39
74LS113	.39
74LS114	.39
74LS125	.49
74LS126	.49
74LS132	.81
74LS136	.39
74LS138	.73
74LS139	.73
74LS151	.75
74LS153	.75
74LS154	1.10
74LS155	.75
74LS156	.75
74LS157	.75
74LS158	.75
74LS160	1.02
74LS161	1.02
74LS162	1.02
74LS163	1.02
74LS164	1.02
74LS168	1.14
74LS169	1.14
74LS170	1.73
74LS173	1.34
74LS174	1.06
74LS175	.84
74LS190	1.18
74LS191	1.18
74LS196	.86
74LS197	.86
74LS247	.79
74LS248	.79
74LS249	.79
74LS253	.84
74LS257	.75
74LS258	.75
74LS266	.39
74LS283	.79
74LS290	.65
74LS293	.65
74LS365	.67
74LS366	.67
74LS367	.67
74LS368	.67
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7406	.25
7407	.25
7408	.21
7409	.21
7410	.21
7411	.21
7412	.21
7413	.25
7414	.69
7416	.25
7417	.25
7420	.21
7421	.25
7423	.35
7425	.35
7426	.25
7427	.33
7428	.28
7430	.21
7432	.25
7433	.30
7437	.25
7438	.25
7440	.21
7442	.53
7443	.63
7445	.70
7446	.70
7447	.70
7448	.70
7450	.21
7451	.21
7453	.21
7454	.21
7459	.23
7460	.21
7470	.30
7472	.30
7473	.30
7474	.30
7475	.49
7476	.32
7480	.70
7482	.70
7483	.70
7485	.89
7486	.28
7489	2.19
7490	.44
7491	.70
7492	.44
7493	.44
7494	.70
7495	.70
7496	.70
74100	1.28
74107	.30
74109	.33
74121	.35
74122	.44
74123	.61
74125	.40
74126	.40
74132	.70
74141	.88
74145	.70
74147	1.63
74148	1.30
74150	1.16
74151	.70
74153	.65
74154	1.03
74155	.70
74156	.70
74157	.70
74160	.88
74161	.88
74162	.88
74163	.88
74164	.96
74165	1.15
74166	1.26
74170	2.64
74173	1.42
74174	.98
74175	.93
74176	.79
74177	.79
74180	.70
74181	2.15
74182	.79
74184	2.19
74185	2.19
74188	3.50
74189	3.50
74190	1.23
74191	1.23
74192	.88
74193	.88
74194	.88
74195	.88
74196	.88
74197	.88
74198	1.49
74199	1.49
74251	1.09
74279	.55
74365	.67
74366	.67
74367	.67
74368	.67
8093	.40
8094	.40
9095	.67
8096	.67
8097	.67
8098	.67
75150	1.16
75450	.88
75451	.61
75452	.61
75453	.61
75454	.61
75491	.81
75492	.84
75493	1.09
75494	1.19
82525	2.19
4000	.23
4001	.23
4002	.23
4006	1.23
4007	.23
4008	.79
4009	.44
4010	.44
4011	.23
4012	.23
4013	.40
4014	.96
4015	.96
4016	.40
4017	1.05
4018	1.05
4019	.23
4020	1.14
4021	1.14
4022	.96
4023	.23
4024	.84
4025	.23
4026	1.68
4027	.40
4028	.89
4029	1.14
4030	.23
4033	1.51
4034	3.50
4035	1.14
4040	1.14
4041	.79
4042	.79
4043	.70
4044	.70
4046	1.86
4049	.40
4050	.40
4051	1.26
4052	1.26
4053	1.26
4060	1.58
4066	.79
4071	.23
4072	.23
4073	.23
4075	.23
4081	.23
4082	.23
4502	.79
4510	1.14
4511	1.05
4514	2.80
4515	2.80
4516	1.23
4518	1.14
4520	1.14
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NE562B	3.83
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uA733CA	.75
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uA748CV	.49
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1N5230B	4.7v	.15	$11/C
1N5231B	5.1v	.15	$11/C
1N5232B	5.6v	.15	$11/C
1N5233B	6.0v	.15	$11/C
1N5234B	6.2v	.15	$11/C
1N5235V	6.8v	.15	$11/C
1N5236B	7.5v	.15	$11/C
1N5237B	8.2v	.15	$11/C
1N5238B	8.7v	.15	$11/C
1N5239B	9.1v	.15	$11/C
1N5240B	10v	.15	$11/C
1N5241B	11v	.15	$11/C
1N5242B	12v	.15	$11/C
1N5243B	13v	.15	$11/C
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NSN374	0.3"	CA	$2.20/Pair
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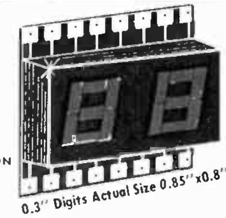
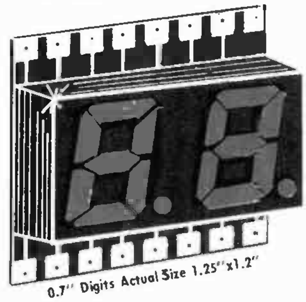
NSN584	0.5"	CA	$2.60/Pair
NSN783	0.7"	CC	$3.00/Pair
NSN784	0.7"	CA	$3.00/Pair

ALL LEADS BROUGHT OUT FOR EASE OF APPLICATION



0.3" Digits Actual Size 0.85"x0.8"



0.7" Digits Actual Size 1.25"x1.2"

0.5" Digits Actual Size 1.05"x1.0"

NEW!

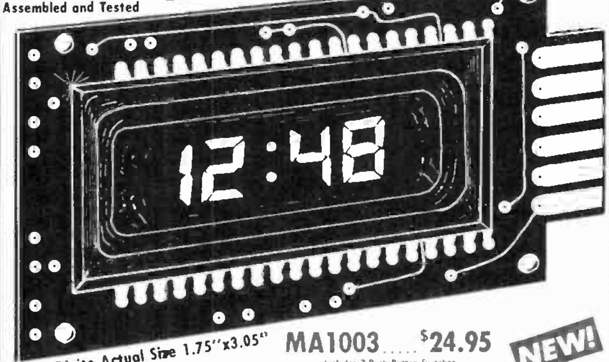
MA1003 CAR CLOCK

12 Hour Only
12 Volt DC
Crystal Time Base
Bright Green Digits
Assembled and Tested

NEW!

NEW — FOR CAR OR BOAT!

The MA1003 bright green flourescent display offers a brilliance that cannot be achieved by LED displays, a feature that sold Detroit!



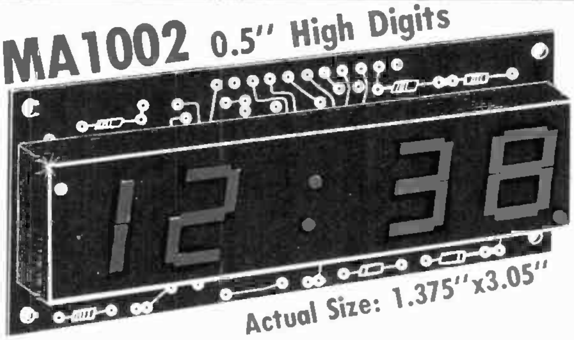
0.3" Digits Actual Size 1.75"x3.05"

MA1003 . . . . $24.95

Includes 3 Push Button Switches

NEW!

MA1002 0.5" High Digits



Actual Size: 1.375"x3.05"

MA1002A 12 Hour AM-PM	$10.50
MA1002C 24 Hour	$10.50
SPECIAL TRANSFORMER & SWITCHES	$3.45

ABOUT OUR CLOCKS

The MA1002 and MA1010 series clock modules by National Semiconductor are fully assembled and tested clocks using a 4 digit LED display and an MOS integrated circuit on the same board. Simply connect switches and our special transformer and you have a fully functioning clock.

The MA1003 clock module is a fully assembled and tested 12 hour clock using a high brilliance green flourescent display and crystal time base making it perfect for car, boat or other portable use. It operates directly from 12 volts DC so no transformer is needed. Our price includes three push button switches for setting the time.

MA1002A	.5" LED 12 Hour AM-PM Clock Module	$10.50
MA1002A SET	Module with Transformer & Switches	$13.95
MA1002C	.5" LED 24 Hour Clock Module	$10.50
MA1002C SET	Module with Transformer & Switches	$13.95
MA1003	12 Volt Car Clock with Switches	$24.95
MA1010A	.84" LED 12 Hour AM-PM Clock Module	$13.00
MA1010A SET	Module with Transformer & Switches	$16.45
MA1010C	.84" LED 24 Hour Clock Module	$13.00
MA1010C SET	Module with Transformer & Switches	$16.45

RADIAL ELECTROLYTICS

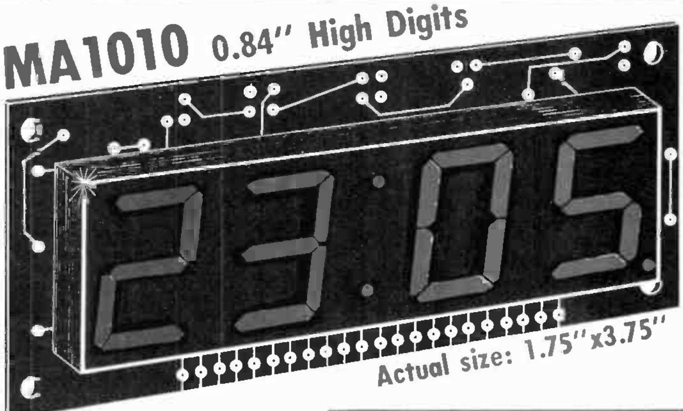
.47/50V	.08	.65/10
1/50V	.08	.65/10
2.2/50V	.08	.65/10
3.3/50V	.08	.65/10
4.7/35V	.08	.65/10
4.7/50V	.08	.68/10
10/16V	.08	.65/10
10/25V	.08	.65/10
10/50V	.10	.75/10
22/16V	.08	.67/10
22/25V	.09	.70/10
22/50V	.12	1.00/10
100/6.3V	.09	.75/10
100/10V	.10	.77/10
100/16V	.11	.85/10
100/25V	.13	1.10/10
100/50V	.21	1.71/10
220/10V	.13	1.08/10
220/16V	.15	1.16/10
220/25V	.21	1.71/10
220/50V	.29	2.35/10
330/10V	.15	1.16/10
330/16V	.21	1.66/10
330/25V	.23	1.86/10
470/10R	.21	1.71/10
470/16V	.23	1.81/10
470/25V	.29	2.35/10
1000/10V	.24	1.96/10
1000/16V	.29	2.35/10
1000/25V	.42	3.33/10
2200/10V	.42	3.33/10
2200/16V	.54	4.30/10
2200/25V	.58	4.67/10
3300/16V	.89	7.14/10

AXIAL ELECTROLYTICS

.47/10V	.11	.90/10
1/30V	.11	.90/10
3.3/35V	.12	.95/10
3.3/50V	.12	1.00/10
4.7/25V	.11	.90/10
4.7/35V	.12	.95/10
4.7/50V	.12	1.00/10
10/25V	.12	1.00/10
10/50V	.14	1.15/10
22/16V	.12	1.00/10
22/25V	.13	1.05/10
22/50V	.17	1.32/10
33/16V	.12	1.00/10
33/25V	.14	1.15/10
33/50V	.19	1.52/10
47/16V	.14	1.15/10
47/25V	.17	1.30/10
47/50V	.21	1.17/10
100/10V	.14	1.13/10
100/16V	.17	1.30/10
100/25V	.20	1.55/10
100/50V	.29	2.30/10
220/10V	.18	1.42/10
220/16V	.20	1.55/10
220/25V	.29	2.35/10
220/50V	.40	3.23/10
330/10V	.14	1.16/10
330/16V	.29	2.35/10
330/25V	.32	2.54/10
470/16V	.32	2.55/10
470/25V	.37	3.00/10
1000/10V	.33	2.65/10
1000/16V	.39	3.15/10
1000/25V	.56	4.50/10
2200/10V	.50	3.96/10
2200/16V	.62	4.95/10
2200/25V	.79	6.36/10
3300/16V	.95	7.63/10
4700/16V	1.09	8.70/10
10000/10V	1.15	9.19/10

Double Digit Discounts Save You Even More!

MA1010 0.84" High Digits



Actual size: 1.75"x3.75"

MA1010A 12 Hour AM-PM	$13.00
MA1010C 24 Hour	$13.00
SPECIAL TRANSFORMER & SWITCHES	$3.45

SEND FOR OUR FREE CATALOG

WE STOCK A WIDE VARIETY OF PARTS NOT IN THIS AD PLUS MANY SPECIALLY PRICED BARGAINS!

DATA BOOKS

TTL IC's 595 p	$4.00
Linear IC's 957 p	$5.00
CMOS 74C 256 p	$3.00
Memory IC's 592 p	$3.00
Interface IC's 464 p	$4.00
Volt. Regs. 128 p	$3.00
Linear Appl. 1 432 p	$4.00
Linear Appl. 2 246 p	$3.00
Audio 196 p	$3.00
MOS/LSI IC's 713 p	$4.00
CMOS 4000 278 p	$3.25
Analog Manual 637 p	$5.95

SLIDE SWITCHES

SPST	.15	1.20/10	10.00/C
SPDT	.19	1.70/10	13.00/C
DPDT	.23	2.00/10	19.00/C

STRANDED HOOK UP WIRE

20 ga PVC	2.50/100'	10.00/500'
22 ga PVC	2.80/100'	11.25/500'
24 ga PVC	2.10/100'	8.50/500'
26 ga PVC	2.10/100'	8.50/500'

50 VOLT DISCS

100 pf	.40/10	3.50/C
220 pf	.40/10	3.50/C
470 pf	.40/10	3.50/C
.001 uf	.40/10	3.50/C
.0022 uf	.40/10	3.50/C
.0047 uf	.40/10	3.50/C
.01 uf	.45/10	3.65/C
.022 uf	.50/10	4.00/C
.047 uf	.70/10	5.60/C
.1 uf	1.35/10	11.50/C

WIRE-WRAPPING TOOL

$5.95

Wraps, Unwraps & Strips 30 ga. Wire

¼ & ½ WATT 5% CARBON FILM RESISTORS

5c each in multiples of 5 per value
$1.70/100 & $12.00/1000 of same value

1 ohm thru 1.0 megohm

I.C. SOCKETS

8 Pin Solder	.17	1.60/10
14 Pin Solder	.20	1.90/10
16 Pin Solder	.22	2.10/10
18 Pin Solder	.29	2.75/10
24 Pin Solder	.38	3.60/10
28 Pin Solder	.45	4.25/10
40 Pin Solder	.63	6.00/10
8 Pin W-W	.24	2.30/10
14 Pin W-W	.26	2.50/10
16 Pin W-W	.30	2.85/10
18 Pin W-W	.60	5.70/10
24 Pin W-W	.96	9.10/10
28 Pin W-W	1.12	10.00/10
40 Pin W-W	.92	8.75/10

HARDWARE

2-56 1/4 Screw	.99/C	7.20/M
2-56 1/2 Screw	.99/C	7.65/M
4-40 1/4 Screw	.55/C	3.60/M
4-40 1/2 Screw	.60/C	4.05/M
6-32 1/4 Screw	.65/C	4.40/M
6-32 1/2 Screw	.75/C	4.85/M
8-32 3/8 Screw	.90/C	5.85/M
8-32 5/8 Screw	.99/C	7.00/M
2-56 Hex Nut	.55/C	3.60/M
4-40 Hex Nut	.55/C	3.75/M
6-32 Hex Nut	.60/C	4.00/M
3-32 Hex Nut	.60/C	4.15/M
No. 2 Lockwasher	.85/C	5.75/M
No. 4 Lockwasher	.45/C	3.00/M
No. 6 Lockwasher	.45/C	3.00/M
No. 8 Lockwasher	.45/C	3.00/M

DOUBLE-DIGIT DISCOUNT SCHEDULE

Merchandise	Discount	Merchandise	Discount
$ 0.00-$24.99	NET	$100.00-$499.99	Less 15%
		$500.00-$999.99	Less 20%
$25.99-$99.99	Less 10%	$1000.00 & Up	Less 25%

Then Add the Standard Charge Below

STANDARD SHIPPING/HANDLING CHARGE

If your merchandise total after discount is between

$ 0.00-$ 4.99	add $2.00	$ 50.00-$99.99	add $0.25
$ 5.00-$24.99	add $0.75	$100.00 & up	No Charge
$25.00-$49.99	add $0.50		

Includes shipping and insurance to USA & Canada

COD ORDERS ACCEPTED FOR SAME DAY SHIPMENT — CALL 218-681-6674

Send for free catalog or mail reader's service card

"Only Quality Components Sold!"

DON'T FORGET TO APPLY DISCOUNT SCHEDULE

DIGI-KEY CORPORATION

Box 677, Thief River Falls, MN 56701 — 218-681-6674

SPECIAL PRICING!

PRIME - HIGH SPEED RAM

21L02-3 400 NS

LOW POWER - FACTORY FRESH

1-24	$1.95 ea	100-199	$1.60 ea
25-99	1.75 ea	200-499	1.45 ea

OVER 500 PCS. **1.39** ea.

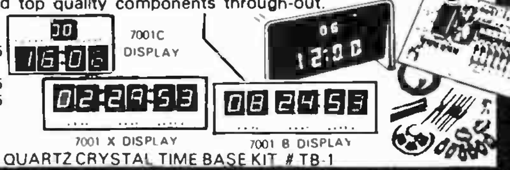
PRINTED CIRCUIT BOARDS for CT-7001 Kits sold separately with assembly info. PC Boards are drilled Fiberglass, solder plated and screened with component layout.
Specify for 7001 *B, C or X* - *$7.95*

6-DIGIT LED CLOCK CALENDAR KIT

DATE-TIME-SNOOZE ALARM & MORE... KIT 7001

FOR THE BUILDER THAT WANTS THE BEST. FEATURING 12 OR 24 HOUR TIME — 29-30-31 DAY CALENDAR. ALARM. SNOOZE AND AUX. TIMER CIRCUITS

Will alternate time (8 seconds) and date (2 seconds) or may be wired for time or date display only, with other functions on demand. Has built-in oscillator for battery back-up. A loud 24 hour alarm with a repeatable 10 minute snooze alarm, alarm set & timer set indicators. Includes 110 VAC/60Hz power pack with cord and top quality components through-out.



KIT - 7001B WITH 6 - .5" DIGITS $39.95
KIT - 7001C WITH 4 - .6" DIGITS & 2 - .3" DIGITS FOR SECONDS $42.95
KIT - 7001X WITH 6 - .6" DIGITS $45.95

KITS ARE COMPLETE (LESS CABINET)
ALL 7001 KITS FIT CABINET I AND ACCEPT QUARTZ CRYSTAL TIME BASE KIT # TB-1

6 DIGIT LED CLOCK KIT #850-4

12/24 HR. OPERATION BIG .4" DIGITS - 50/60 HZ OPERATION.

KIT INCLUDES
- INSTRUCTIONS
- QUALITY COMPONENTS
- 50 or 60 Hz OPERATION
- 12 or 24 HR OPERATION

Kit # 850-4 will fit Plexiglas Cabinet II

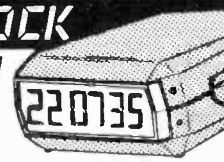
6 LED Readouts (FND-359 Red, com. cathode)
1 MM5314 Clock Chip (24 pin)
13 Transistors
3 Switches
6 Capacitors
5 Diodes
9 Resistors
24 Molex pins

$11.95 ea. QTY. 1-5
$10.95 ea. QTY. 6-11
$9.95 ea QTY. 12 OR MORE

"Kit #850-4 will furnish a complete set of clock components as listed. The only additional items required are a 7-12 VAC transformer, a circuit board and a cabinet, if desired."

PRINTED CIRCUIT BOARD FOR KIT #850-4, SCREEN PRINTED DRILLED AND SOLDER PLATED FIBERGLASS $2.95
MINI-BRITE RED LED'S (FOR COLON IN CLOCK DISPLAY) ... Pkg. of 5 - $1.00
MOLDED PLUG TRANSFORMER 115/10 VAC (WITH CORD) $2.50
NOTE: Entire Clock may be assembled on one PC Board or Board may be cut to remote display.

MOBILE LED CLOCK



12/24 HR **.4" DIGITS!**

MODEL #2001 — 12 VOLT AC or DC POWERED

- 6 JUMBO .4" RED LED'S BEHIND RED FILTER LENS WITH CHROME RIM
- SET TIME FROM FRONT VIA HIDDEN SWITCHES • 12/24 Hr. TIME FORMAT
- STYLISH CHARCOAL GRAY CASE OF MOLDED HIGH TEMP. PLASTIC
- BRIDGE POWER INPUT CIRCUITRY — TWO WIRE NO POLARITY HOOK-UP
- OPTIONAL CONNECTION TO BLANK DISPLAY (Use When Key Off In Car, Etc.)
- TOP QUALITY PC BOARDS & COMPONENTS • EXCELLENT INSTRUCTIONS
- MOUNTING BRACKET INCLUDED

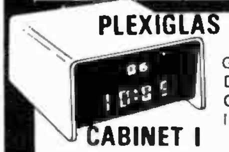
KIT #2001 COMPLETE KIT (Less 9V. Battery) **$29.95** — 3 OR MORE **$27.95** EA — 115 VAC Power Pack #AC-1 **$2.50** EA.

ASSEMBLED UNITS ORDER #2001 WT — WIRED & TESTED (LESS 9V. BATTERY) **$39.95** EA — 3 OR MORE **$37.95** EA
WIRED FOR 12 HR OP. IF NOT SPECIFIED OTHERWISE

60 HZ. XTAL TIME BASE

Will enable Digital Clock Kits or Clock-Calendar Kits to operate from 12V DC.
1"x2" PC Board
Power Req: 5-15V (2.5 MA. TYP.)
Easy 3 wire hookup
Accuracy: ± 2PPM
#TB-1 (Adjustable)
Complete Kit **$4.95** ea
Wir & Cal $9.95

PLEXIGLAS CABINETS



Great for Clocks or any LED Digital project. Clear-Red Chassis serves as Bezel to increase contrast of digital displays.

CABINET I 3"H, 6¼"W, 5½"D
CABINET II 2½"H, 5"W, 4"D
Black, White or Clear Cover
$6.50 ea.

RED OR GREY PLEXIGLAS FOR DIGITAL BEZELS
3"x6"x1/8" — 95¢ ea. 4/$3

SEE THE WORKS Clock Kit — Clear Plexiglas Stand

- 6 Big .4" digits
- 12 or 24 hr. time
- 3 set switches
- Plug transformer
- all parts included

Plexiglas is Pre-cut & drilled
Kit #850-4CP
Size: 6"H, 4½"W, 3"D
$23.50 ea **2/$45.**
A SUPER CLOCK!

JUMBO DIGIT CLOCK

A complete Kit (less Cabinet) featuring: six .5" digits, MM5314 IC 12/24 Hr. time 50/60 HZ., Plug Transformer, Line Cord, Switches, and all Parts. (Ideal Fit in Cabinet II)
Kit # 5314-5 **$19.95** **2/$38.**
WITH PC Boards

JUMBO DIGIT CONVERSION KIT — $ 9.95 ea.

Convert small digit LED clock to large .5" displays. Kit includes 6 LED's, Multiplex PC Board & easy hook-up info.
Kit # JD-1CC For common Cathode
Kit # JD-1CA for common Anode

TELEPHONE FORMAT KEYBOARD

BY Chomerics
EF-21360
2-1/4"x3"
5/32" thick
$4.95
6/$28.

25 AMP BRIDGE

$1.95 ea. 3/$5.00

NEW LSI TECHNOLOGY
FREQUENCY COUNTER KIT
8 LARGE .4" RED LED DIGITS

Kit #FC-50 • 8 IC's • XTAL TIME BASE

A truly "State of the Art" counter using quality components throughout.

KIT INCLUDES: DETAILED INSTRUCTIONS, XTAL, TOP QUALITY FIBERGLASS DOUBLE SIDED PC BOARD, IC'S WITH SOCKETS AND ALL PARTS LESS POWER SUPPLY AND CABINET.

50 MHZ COUNTER KIT	#FC-50	$69.95
5 VOLT REGULATED 1 AMP POWER SUPPLY KIT	#PS-02	$9.95
350 MHZ PRESCALER KIT	#PSL-350	23.95
650 MHZ PRESCALER KIT	#PSL-650	$29.95
CABINET [& MTG HARDWARE]	#CAB III	$19.95

[CABINET WILL HOUSE #FC-50, #PS-02, AND A PRESCALER]

Fairchild Super Digit FND-359

.4" Char. Ht. 7 segment LED RED Com. Cath. Direct pin replacement for popular FND-70.

95¢ ea. 10/$8.50 100/$79.00

SET OF 6 FND-359 WITH MULTIPLEX PC BOARD $6.95

NYLON WIRE TIES

8" TIE-WRAP 100/$1.95
4" TIE-WRAP 100/$1.75

PLUG TRANSFORMERS

12VAC at 150 MA $ 2.50
12VAC at 500 MA 3.50
7VAC at 1.75 VA $3.50

SCHOTTKY TTL

74S00	$ .35
74S01	.40
74S04	.55
74S05	.60
74S09	.55
74S10	.40
74S20	.50
74S22	.45
74S40	.45
74S50	.45
74S51	.55
74S60	.85
74S64	.55
74S74	.85
74S75	1.75
74S78	1.50
74S86	95
74S107	.95
74S112	.95
74S113	1.40
74S114	95
74S133	.75
74S134	.75
74S138	1.75
74S139	1.50
74S151	1.95
74S153	1.95
74S155	1.95
74S156	1.95
74S157	1.80
74S158	2.50
74S174	2.50
74S175	2.50
74S181	2.95
74S182	1.95
74S251	2.75

DIGITAL CLOCK IC's

MM5312	$ 4.95
MM5314	3.95
MM5375AB	3.95
CT-7001	7.95
CT-7002	13.95
MM5369	2.50

LED DRIVERS

7447	$ 95
7448	95
75491	65
75492	.65
9368	2.50

PRESCALE

11C90DC	$15.95
95H90	9.95

VOLTAGE REGULATORS

LM309H	TO-5	$ .95
LM309K	TO-3	1.25
7805	TAB	.95
7812	TAB	1.25
7812	TO-3	1.50
7815	TO-3	1.25
7815	TAB	1.25
78L15	TO-5	.75
7824	TO-3	1.25
723	DIP	.75
723	TO-5	75

PROM

1702	E Prom $8.95
5203	E Prom $8.95

SPECIAL IC'S

7207A	INTERSIL	$19.95
7208	INTERSIL	$ 4.95
MC14553	MOT	$ 9.95
MC14410	MOT	$12.50
2513	SIG	$ 9.95

IC SOCKETS

PINS	1-24	25	100
8	$ 25	$ 22	$ 20
14	.25	22	.20
16	.28	.25	23
18	.31	.28	.26
24	.50	.45	40
28	.60	.55	.50
40	.75	.70	.65

XTAL

5.242880 MHZ $4.95
3.579545 MHZ $1.95

MOLEX PINS

$9.95 Reel of 1000
100 for $1.25

TRANSISTORS

2N2222 A	TO-18	3/$1.00
2N2712	TO-98	5/$1.00
2N3415	TO-9	5/$1.00
2N3704	TO-92	5/$1.00
2N4400	TO 92	5/$1.00
2N4125	TO-92	5/$1.00
2N4249	TO-92	5/$1.00
2N4437	TO-92	5/$1.00
2N6027	PUT	2/$1.00
2N5457	N J Fet	2/$1.00

DIODES

IN 4002	1A, 100 PIV	12/$1.00
IN 4005	1A, 600 PIV	11/$1.00
IN 4007	1A, 1000 PIV	10/$1.00
RECTIFIER	2.5A, 1000 PIV	4/$1.00
IN 914	SIL. SIGNAL	20/$1.00
IN 4148	SIL. SIGNAL	20/$1.00
DYAC	28V	4/$1.00

LINEAR

555 TIMER	2/$1.00
556 DUAL TIMER	.95
565 PLL	95
566 FUNCTION GEN.	1.75
567 TONE DECODER	1.75

TRANSISTOR SOCKET

TO-5/18 GOLD PINS
5 $1.00

7-SEG LED

COMMON CATHODE

	COLOR	HT	DEC PT	PR EA
FND-359	RED	4"	RHDP	$ 95
FND 503	RED	5"	RHDP	$1 35
DL 750	RED	6"	LHDP	$2 95
XAN 654	GREEN	6"	NDP	$1 95
XAN 664	RED	6"	NDP	$1 95

COMMON ANODE

DL 747	RED	6"	LHDP	$1 95
XAN-72	RED	3"	LHDP	$1 25
MAN-72	RED	3"	LHDP	$1 25
XAN-81	YELLOW	3"	RHDP	$1 75
XAN 351	GREEN	3"	RHDP	$1 50
XAN-362	ORANGE	3"	LHDP	$1 50
XAN 662	RED	6"	NDP	$1 95
XAN 692	RED	6"	NDP	$1 95

OP AMPS

3/$1.00

301	TO-5
709	DIP
709	TO 5
741	DIP
741	M-DIP
741	TO-5
747	TO 5

DISCRETE LED's

JUMBO RED
10 FOR $1.00
100 FOR $9.50

PC TRIM POTS

25K 6/$1.00
4.7K 6/$1.00

SPECTROL 10K 10 TURN
95c
4/$3.00

CMOS

	ea.
4001	$ .20
4002	.20
4010	.40
4011	.20
4013	.40
4015	.95
4016	.40
4023	.20
4025	.20
4027	.40
4028	.85
4030	.35
4042	.75
4044	.60
4046	1.75
4049	.40
4050	.40

AUTO BURGLAR ALARM KIT

AN EASY TO ASSEMBLE AND EASY TO INSTALL ALARM PROVIDING MANY FEATURES NOT NORMALLY FOUND. KEYLESS ALARM HAS PROVISION FOR POS. & GROUNDING SWITCHES OR SENSORS. WILL PULSE HORN RELAY AT 1HZ RATE OR DRIVE SIREN. KIT PROVIDES PROGRAMMABLE TIME DELAYS FOR EXIT, ENTRY & ALARM PERIOD. UNIT MOUNTS UNDER DASH - REMOTE SWITCH CAN BE MOUNTED WHERE DESIRED. CMOS RELIABILITY RESISTS FALSE ALARMS & PROVIDES FOR ULTRA DEPENDABLE ALARM. DO NOT BE FOOLED BY LOW PRICES! THIS IS A TOP QUALITY COMPLETE KIT WITH ALL PARTS INCLUDING DETAILED DRAWINGS AND INSTRUCTIONS OR AVAILABLE WIRED AND TESTED.

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VARIABLE REGULATED 1 AMP POWER SUPPLY KIT

- VARIABLE FROM 4 to 14V
- SHORT CIRCUIT PROOF
- 723 IC REGULATOR
- 2N3055 PASS TRANSISTOR
- CURRENT LIMITING AT 1 Amp

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7400 TTL

7400	21	7442	1 08	74121	55
7401	21	7448	1 15	74122	49
7402	21	7450	26	74123	1 05
7404	21	7451	27	74125	60
7405	24	7453	27	74126	81
7406	45	7454	41	74132	3 00
7407	45	7460	22	74141	1 15
7408	25	7472	39	74150	1 10
7409	25	7473	45	74151	1 25
7410	20	7474	45	74153	1 35
7411	30	7475	80	74154	1 25
7413	85	7482	1 75	74155	1 21
7416	43	7483	1 15	74157	1 30
7417	43	7485	1 12	74161	1 45
7420	21	7486	45	74164	1 65
7422	1 50	7489	2 49	74165	1 65
7425	43	7490	69	74166	1 70
7427	37	7491	1 20	74174	1 95
7428	33	7492	82	74175	1 95
7430	26	7493	82	74180	1 05
7432	31	7494	91	74181	3 55
7437	47	7495	91	74191	1 50
7438	40	7496	91	74195	1 00
7440	21	74100	1 25	74197	1 00
7441	1 10	74107	49	74298	1 30

5400 SERIES

5400	1 00	5475	1 50
5404	1 25	5486	1 90
5410	1 00	5493	2 00
5426	1 25	54100	1 80
5473	1 50	54LS04	1 00

C MOS

4001AE	29	4022AE	1 20
4002AE	29	4023AE	29
4007AE	29	4024AE	1 50
4009AE	58	4025AE	35
4010AE	58	4026AE	1 49
4011AE	29	4028AE	1 60
4012AE	29	4029AE	2 90
4013AE	52	4030AE	65
4015AE	1 25	4037AE	4 50
4016AE	65	4040AE	2 40
4018AE	1 10	4044AE	1 50
4019AE	65	4047AE	2 75
4020AE	1 75	4049AE	75
4021AE	1 50	4050AE	75

MOTOROLA CIRCUITS

		MC1741CG	98
MC725P	1 50	MC1804P	98
MC740L	1 55	MC1806P	98
MC790P	1 50	MC1810P	98
MC832P	48	MC2053L	45
MC1004L	1 25	MC3004L	1 32
MC1008L	1 25	MC3006P	1 44
MC1010L	1 25	MC3007P	1 32
MC1011L	1 25	MC3021L	2 15
MC1036L	12 50	MC3021P	2 15
MC1037L	12 50	MC3060L	2 65
MC1352P	1 05	MC3062L	3 00
MC1406CP	3 95	MC4024P	2 20
MC1468L	2 90	MC14501CP	31
MC1469R	2 50	MC14502CP	1 18
MC1510G	8 00	MC14507CP	82
MC1514L	4 50	MC14510CP	2 40
MC1550G	1 50	MC14511CP	2 76
MC1558	4 37	MC14512CP	1 92
MC1595L	6 25	MC14519CG	94
MC1596G	3 31	MC14528CP	1 74
MC1723CG	1 25	MC4044P	4 80

JAPANESE CIRCUITS

AN136	2 90	HA1312	4 05	STK056	11 35	TA7201P	6 40
AN203	3 75	HA1322	5 20	STK415	11 50	TA7203P	7 00
AN208	4 75	HA1339	5 20	TA7045M	3 50	TA7204P	6 50
AN210	3 10	LA1201	4 25	TA7054P	3 05	TA7205P	6 50
AN211	3 30	LA1364	4 70	TA7055P	5 50	TA78005M	2 50
AN214	4 90	LA1366	6 00	TA7060P	1 85	TA78005P	1 95
AN217	3 30	LA1367	5 90	TA7061P	2 25	TA78012M	2 50
AN229	6 35	LA3301	4 85	TA7149P	4 00	TA78012P	1 95
AN234	5 75	LA4030	4 85	TA7063P	2 25	TA78015M	2 50
AN239	6 50	LA4031P	3 50	TA7074P	4 90	TA78015P	1 95
AN241	3 20	LA4051P	4 65	TA7075P	4 90	TC9100P	12 00
AN245	6 50	TBA810S	3 50	TA7076P	4 55	UPC16C	2 50
AN274	3 95	LD3080	4 00	TA7089P	2 90	UPC20C	5 00
AN277B	3 40	LD3120	3 10	TA7102	5 15	UPC41C	3 95
AN288	4 80	LD3141	2 40	TA7106P	3 25	UPC48C	3 95
AN328	4 05	M5112	5 40	TA7120P	2 20	UPC554C	3 90
AN343	3 90	M5115PR	4 80	TA7120P-C	2 20	UPC563H2	8 00
BA511	3 50	M5155	2 85	TA7122AP	2 30	UPC566H	2 25
BA521	3 95	SG613	5 40	TA7124P	1 85	UPC575C	4 10
HA1158	6 30	STK011	10 50	TA7146P	4 10	UPC1001H2	5 15
HA1159	6 60	STK015	6 50	TA7150P	4 55	UPC1020H	5 50
HA1202	3 10	STK025	12 50	TA7153P	6 90	UPC1025	5 50
HA1306W	5 20	STK032	14 20	TA7200P	6 25		

74L SERIES TTL

74L00	33	74LS04	45	74LS113	98
74L10	33	74LS10	39	74LS138	1 89
74L30	33	74LS20	39	74LS174	2 50
74L42	1 50	74LS51	39	74LS386	5 50
74L86	69	74LS74	65	74S153	2 25
74LS00	39	74LS112	65	74S387	1 95

74H00 TTL

74H00	33	74H11	33	74H53	39
74H01	33	74H20	33	74H55	39
74H04	33	74H21	33	74H73	59
74H05	35	74H30	33	74H74	59
74H10	33	74H40	33	74H76	60

MISC CIRCUITS

BC184L	60	LM309K	1 95	SN15844N	55
CA3001	75	LM351AN	70	SN15946	55
CA3005	80	LM741CP	40	SN158097N	60
CA3006	1 10	LM1458M	65	SN72560P	4 50
CA3018	1 60	MFC9020	1 15	SN72741ON	85
CA3018A	1 60	MR995A	1 05	SN72741C	45
CA3026	2 15	MSC9967P	1 50	SN72748P	49
CA3035	2 45	N5558	55	UA703C	95
CA3039	1 35	N8598B	5 00	UA709C	40
CA3058	1 90	NE555V	45	USF7733393	2 40
CK707P	45	PA771131	45	995879	6 50
C5134J	1 15	PL994551	45	996079	12 50
C5135J	1 20	RC14370B	35	998979	9 00
C5136	1 25	SC9962P	70	936-5D	1 10
IC3(GE)	1 50	SC9966P	1 25	9313DC	1 20
LM301AN	35	SN15830N	50	93L28DC	2 75

POSITIVE VOLTAGE REGULATORS

LM340K-5	1 95
LM340K-6	1 95
LM340K-8	1 95
LM340K-12	1 95
LM340K-15	1 95
LM340K-18	1 95
LM340K-24	1 95
LM340T0 5	1 75
LM340T0 6	1 75
LM340T0 8	1 75
LM340T0 12	1 75
LM340T0 15	1 75
LM340T0 18	1 75
LM340T0 24	1 75

NEGATIVE REGULATORS AVAILABLE

IC's ON THE MOVE

BBD BUCKET BRIGADE DEVICE
MM3C01 19 50 MN3002 11 70 MM3003 9 45
HALL IC DN834 1 25 DN837 1 50
DN835 1 35 DN838(NEW)
SN76001 1 75 SN76002 1 95
PLL02A MIDLAND PHASE LOCK LOOP 12 00

MICROPROCESSOR CHIPS

1404A	3 25	2102	2 50	MM5013	3 25
C1702A	19 95	C2708	95 00	8008	19 95
2101	6 95	C4702A	19 95	8080A	29 95

MK4200 P-11 4096x1 Bit Dynamic Ram 9 95
C5101-3 1024 Bit (256x4) Static C-Mos Ram 4 50
MC14514 4 Bit Latch 4 to 16 Line Decoder 4 25
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ELECTROLYTIC CAPACITORS

2 2MF50	AXIAL LEADS	15
3 3MF10	AXIAL LEADS	15
3 3MF10	NO POLARITY	15
10MF25	AXIAL LEADS	15
10MF50	AXIAL LEADS	15
10MF150	AXIAL LEADS	20
25MF35	AXIAL LEADS	15
30MF25	AXIAL LEADS	15
47MF25	RADIAL LEADS	15
47MF50	RADIAL LEADS	20
100MF16	RADIAL LEADS	15
100MF25	RADIAL LEADS	20
500MF50	AXIAL LEADS	60
1000MF35	AXIAL LEADS	65

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½w5%	08	07	06

STANDARD RESISTANCE VALUES OHMS

10	270	820	4 7K	27K
22	300	910	5 1K	33K
47	330	1 0K	6 8K	47K
51	470	1 5K	7 5K	100K
100	510	2 2K	8 2K	330K
150	560	2 7K	10K	1 0M
220	680	3 3K	15K	
240	750	3 9K	22K	

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Mos Fet Pac	10 Asst (many top #s Case T072)	$0 99
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130079	4 00	IP20-0123	2 75
1300821	65	IP20-0131	2 50
13-0122	1 75	IP20-0141	3 00
83-0005	2 00	IP20-0142	3 00
83-0007	2 50	IP20-0139	43
83-0008	2 00	IP20-0154	6 00
83-0015	3 00	IP20-0155	2 50
IP20-0005	3.00	IP20-0161	4 00
IP20-0016	40	IP20-0177	2 75
IP20-0034	85	IP20-0176	2 85
IP20-0037	85	IP20-0191	72
IP20-0045	2 00		
IP20-0073	2 75		
IP20-0093	2 50		

POPULAR JEDEC SEMICONDUCTORS

1N34	25	2N918	60	2N2218	25	2N2906A	30	2N3646	14	2N4220A	45
1N60	25	2N930	25	2N2218A	30	2N2907	25	2N3730	2 50	2N4234	95
1N270	40	2N956	30	2N2219	25	2N2907A	30	2N3731	3 75	2N4400	16
1N914	10	2N960	90	2N2219A	30	2N2913	75	2N3740	1 00	2N4401	16
		2N962	95	2N2221	25	2N2914	1 20	2N3771	1 75	2N4402	16
2N173	1 75	2N967	95	2N2221A	30	2N2916A	3.65	2N3772	1 90	2N4403	20
2N174	3 50	2N1136	1 75	2N2222	25	2N3019	50	2N3773	3.00	2N4409	.16
2N178	90	2N1142	2 25	2N2222A	30	2N3053	30	2N3819	40	2N4410	16
2N327A	1 15	2N1300	1 00	2N2223	1 00	2N3054	70	2N3823	70	2N4416	.75
2N334	1.20	2N1301	1 10	2N2270	40	2N3055	.75	2N3856	.20	2N5061	.30
2N336	90	2N1302	1 25	2N2323	1 00	2N3227	1.00	2N3866	85	2N5064	.50
2N338A	1.05	2N1303	70	2N2324	1 35	2N3247	3.40	2N3903	16	2N5130	20
2N398B	1.50	2N1304	1 25	2N2325	2.00	2N3250	.50	2N3904	16	2N5133	15
2N404	75	2N1305	75	2N2326	2.85	2N3375	6.50	2N3905	16	2N5138	.15
2N443	2 50	2N1306	1 35	2N2327	3.80	2N3393	20	2N3906	16	2N5198	3.75
2N456	1 30	2N1307	75	2N2328	4 25	2N3394	17	2N3925	3.75	2N5294	50
2N501A	3.00	2N1308	1 50	2N2329	4 75	2N3414	17	2N3954	3.50	2N5296	.50
2N508A	45	2N1309	90	2N2368	25	2N3415	.18	2N3954A	3.75	2N5306	.20
2N555	75	2N1552	3.25	2N2369	25	2N3416	19	2N3955	2 45	2N5354	.20
2N652A	1.25	2N1554	1.25	2N2484	32	2N3417	.20	2N3957	1 25	2N5369	.20
2N677	6 00	2N1557	1 15	2N2712	18	2N3442	1.85	2N4036	.75	2N5400	.40
2N706	.25	2N1560	2 80	2N2894	40	2N3553	1.50	2N4037	.60	2N5401	.50
2N706B	75	2N1605	35	2N2903	3.30	2N3563	.20	2N4093	85	2N5457	.35
2N711	90	2N1613	.30	2N2904	.25	2N3565	.20	2N4124	.16	2N5458	.30
2N711B	1 10	2N1711	.30	2N2904A	.30	2N3838	.20	2N4126	.16	CIO3Y	.25
2N718	.25	2N1907	4 10	2N2905	25	2N3642	.20	2N4141	.20	C106B1	.50
2N718A	.30	2N2060	1.85	2N2905A	.30	2N3643	.20	2N4142	.20		
2N720A	50	2N2102	.40	2N2906	.25	2N3645	.20	2N4143	20		

JAPANESE TRANSISTORS ★ CB, AUDIO, INDUSTRIAL

2SA52	60	2SC206	1 00	2SC774	1 75	2SC1173	95	2SD77	1 00
2SA316	75	2SC240	1 10	2SC775	2 75	2SC1175	65	2SD81	3 25
2SA473	75	2SC291	65	2SC776	3 00	2SC1209	55	2SD88	1 50
2SA483	1 95	2SC292	3 00	2SC777	4 00	2SC1213	75	2SD118	3 25
2SA489	80	2SC320	75	2SC778	4 00	2SC1226A	1 25	2SD130	1 25
2SA490	70	2SC352	75	2SC781	3 00	2SC1237	4 50	2SD141	2 25
2SA505	70	2SC353	75	2SC783	1 00	2SC1239	4 00	2SD151	2 25
2SA564	50	2SC371	70	2SC784	70	2SC1243	1 50	2SD170	2 00
2SA628	65	2SC372	70	2SC785	1 00	2SC1293	85	2SD180	2 75
2SA643	85	2SC394	70	2SC789	1 00	2SC1306	4 75	2SD201	1 95
2SA647	2 75	2SC458	70	2SC793	2 50	2SC1307	5 75	2SD218	4 75
2SA673	85	2SC460	70	2SC796	3 15	2SC1308	4 75	2SD235	1 00
2SA679	3 75	2SC478	80	2SC797	2 50	2SC1317	60	2SD300	2 50
2SA682	85	2SC481	1 85	2SC798	3 10	2SC1318	70	2SD313	1 10
2SA699	1 30	2SC482	1 75	2SC799	4 25	2SC1325	4 95	2SD315	75
2SA699A	1 45	2SC491	2 50	2SC802	3 75	2SC1327	70	2SD316	2 50
2SA705	55	2SC495	1 10	2SC803	4 00	2SC1338	1 75	2SD317	1 25
2SA815	85	2SC497	1 60	2SC815	75	2SC1346	80	2SD318	95
2SA816	85	2SC502	1 50	2SC828	75	2SC1347	80	2SD325	1 25
		2SC515	80	2SC829	75	2SC1364	1 50	2SD341	95
2SB22	65	2SC517	4 25	2SC830	1 60	2SC1377	5 50	2SD350	3 25
2SB54	70	2SC535	75	2SC838	70	2SC1383	75	2SD352	80
2SB56	70	2SC536	65	2SC839	85	2SC1384	85	2SD380	5 70
2SB77	70	2SC537	70	2SC922	55	2SC1409	1 25	2SD389	75
2SB128	2 25	2SC563	2 50	2SC929	70	2SC1410	1 25	2SD390	75
2SB152	4 50	2SC607	1 25	2SC930	65	2SC1447	1 25		
2SB173	55	2SC614	3 80	2SC938	65	2SC1448	1.25	2SF8	3.00
2SB175	55	2SC615	3 90	2SC943	1 50	2SC1449	1 30	2SCF8	3.50
2SB178	1 00	2SC616	4.15	2SC945	65	2SC1475	1 50	2SCF6	1.25
2SB186	60	2SC617	4.25	2SC959	3 15	2SC1507	1 25	HEPS3001	3.25
2SB187	60	2SC620	.80	2SC960	2 75	2SC1509	1 25	JSP7001	75
2SB235	7 00	2SC627	1.75	2SC984	1.50	2SC1569	1 25	MRF8004	3 00
2SB303	65	2SC642	3.50	2SC996	4.90	2SC1674	1 75	MPS8000	1 25
2SB324	1 00	2SC643	3 75	2SC1010	.80	2SC1675	1 75	MPS8001	1 25
2SB337	2 10	2SC644	70	2SC1012	80	2SC1678	5.50	MPSU02	50
2SB367	1 60	2SC681	2.50	2SC1013	1.50	2SC1679	4.75	MPSU31	4 00
2SB370	65	2SC684	2 10	2SC1014	1.50	2SC1756	1.25	SK3047	3.75
2SB405	85	2SC687	2.50	2SC1017	1.50	2SC1760	2.15	SK3048	3.25
2SB407	1 65	2SC696	3.00	2SC1018	1.50	2SC1816	4.50	SK3049	4.75
2SB415	.85	2SC699	4.75	2SC1030	4.75	2SC1908	.70	SK3054	1 25
2SB461	1 25	2SC710	70	2SC1051	2.50	2SC1909	4.75	2SK19	1 75
2SB463	1 65	2SC711	70	2SC1060	.75	2SC1957	1.50	2SK30	1.00
2SB471	1 75	2SC712	.70	2SC1061	1.65	2SC1973	1.50	2SK33	1.20
2SB474	1 50	2SC713	.70	2SC1069	3.50	2SC1974	4.90	2SK41	1.75
2SB476	1 25	2SC731	3.00	2SC1079	3.75	2SC1975	4.90	3SK22Y	2.75
2SB481	2 10	2SC732	70	2SC1080	3 75	2SC2028	1.10	3SK40	2 75
2SB492	1 25	2SC733	70	2SC1096	1.20	2SC2029	4.75	3SK45	2.75
2SB495	95	2SC735	70	2SC1098	1.15	2SC2074	3.00	3SK49	2 75
2SB507	90	2SC739	.70	2SC1115	2.75			4004	3.00
2SB511	70	2SC715	.70	2SC1166	.70	2SD45	2.00	4005	3.00
2SB531	3.00	2SC756	3.00	2SC1167	4.25	2SD65	.75	40080	1.25
2SB556	3 50	2SC762	1.90	2SC1170	4.00	2SD68	.90	40081	1.50
2SB135	95	2SC773	.85	2SC1172B	4.25	2SD72	1.00	40082	3.00

SILICON UNIJUNCTIONS

2N2160	.65	MU4892	.50
2N2646	.45	MU4893	.50
2N2647	.55	MU4894	.50
2N4851	.75	2N6027	55
2N4852	.75	2N6028	.70
2N4870	.50	D5E37	.35
2N4871	.50	MU10	.35
MU4891	.50	MU20	.40

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FREE KIT Catalog contains Test and Experimenter's Equipment. Dage Scientific Instruments, Box 1054P, Livermore, CA 94550.

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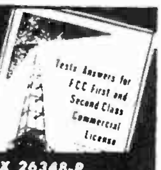

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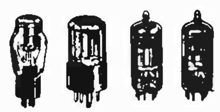

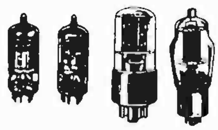

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12AU7	1.29	34CE3	1.68
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12AX7	1.32	35W4	.93
12AZ7	1.83	35Z5GT	1.49
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12BA6	1.22	38HE7	3.08
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12BH7	1.67	42EC4A	1.77
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12DQ6	2.21	50B5	1.28
12DW4	2.19	50C5	1.29
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7416	.35	7486	.40	74173	1.49
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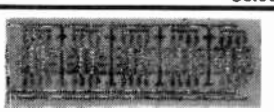

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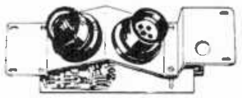

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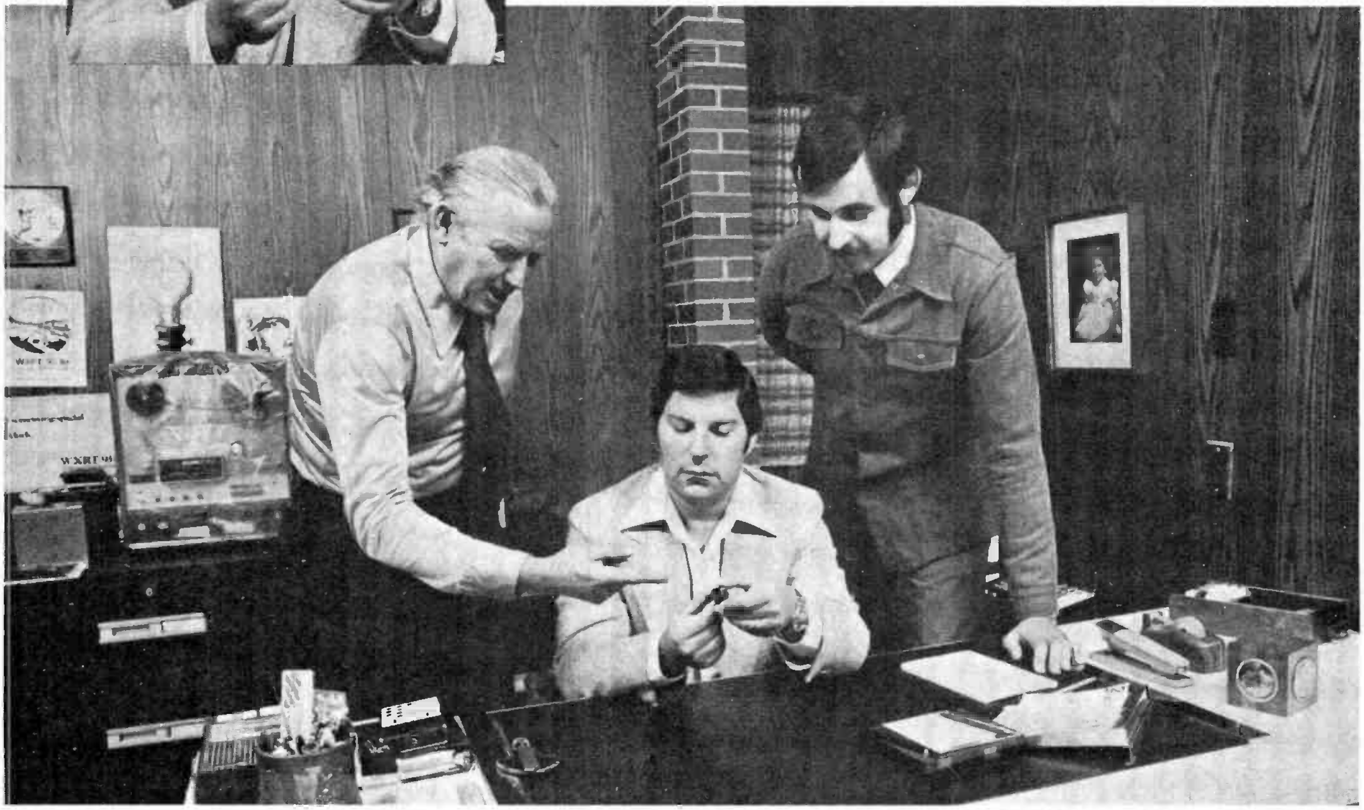

Daniel Lee, President and General Manager, discussing Stylus Replacement Policy with Howard Williams, Chief Engineer and Ken Rasek, Audio Engineer.

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John Bell hands new record to Scott McConnell.

Air personality, John Bell prepares to play a record.

For over 10 years, the station has used the Stanton product in its turntables. Today, it even uses the 681 Triple-E for disc-to-air playback and, although this stylus was not designed for back-cueing, the engineers and announcers report no problem (they even use them on their AM operation, WSBC).

Leading radio stations around the nation depend on Stanton 681 Calibration series cartridges, because they offer improved tracking at *all* frequencies . . . they achieve perfectly flat frequency response to beyond 20 kHz. Its stylus assembly, even though miniaturized, possesses greater durability than had been thought possible to achieve.

Each 681 Triple-E is guaranteed to meet its specifications within exacting limits, and each one boasts the most meaningful warranty possible . . . an individual calibration test result is packed with each unit.

Whether your usage involves recording, broadcasting or home entertainment, your choice should be the choice of the professionals . . . The Stanton 681.

For further information, write to:
Stanton Magnetics, Terminal Drive,
Plainview, N.Y. 11803.

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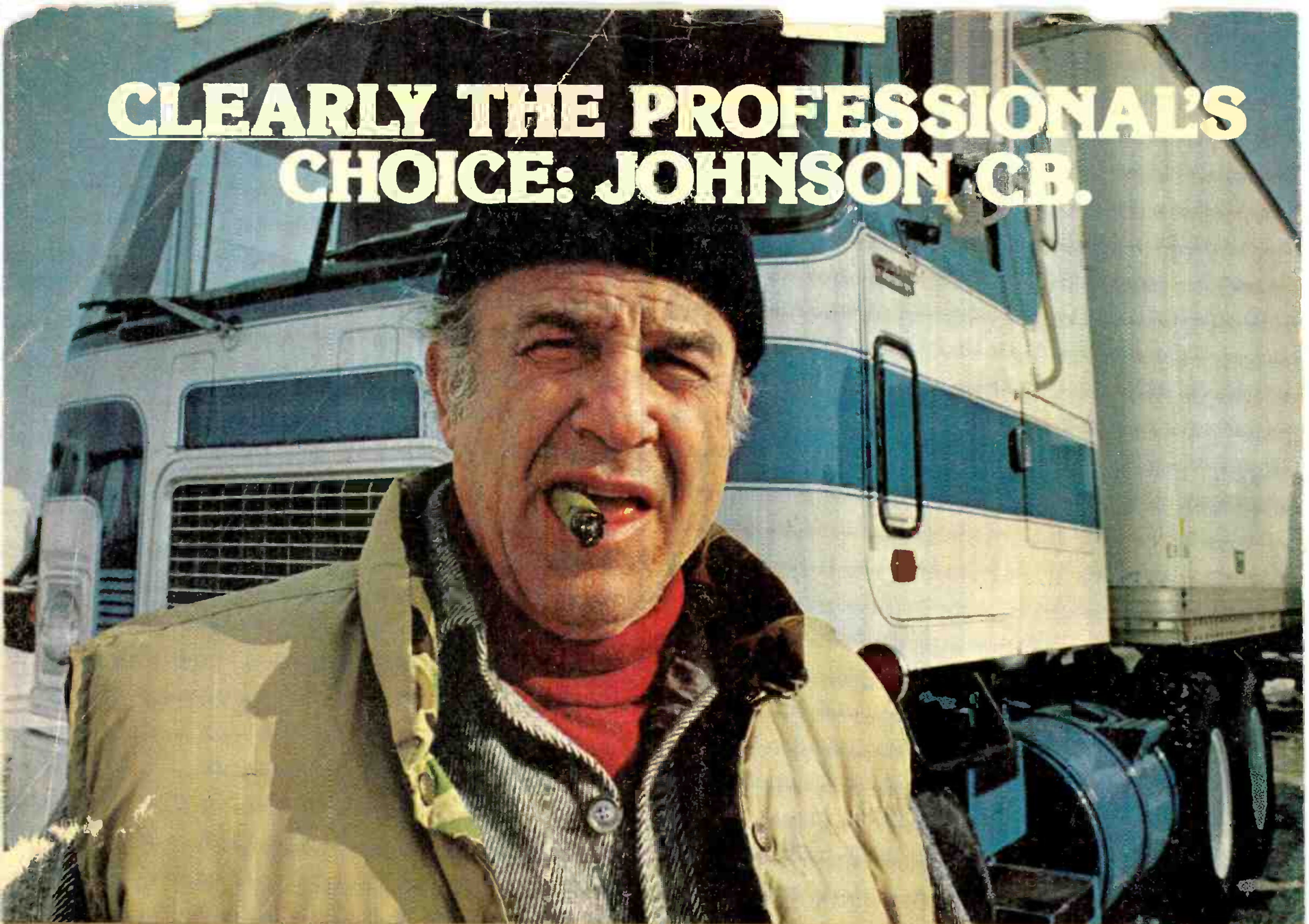

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*Independent Trucker Survey results available upon request.

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